Security of Radioactive Sources

Proceedings of an international conference held in Vienna, Austria, 10–13 March 2003, organized by the International Atomic Energy Agency, hosted by the Government of Austria, co-sponsored by the Government of the Russian Federation and the Government of the United States of America, and in co-operation with the European Commission, the European Police Office, the International Criminal Police Organization and the World Customs Organization

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International Atomic Energy Agency

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SECURITY OF RADIOACTIVE SOURCES

PROCEEDINGS SERIES

SECURITY OF RADIOACTIVE SOURCES

PROCEEDINGS OF AN INTERNATIONAL CONFERENCE HELD IN VIENNA, AUSTRIA, 10–13 MARCH 2003, ORGANIZED BY THE INTERNATIONAL ATOMIC ENERGY AGENCY, HOSTED BY THE GOVERNMENT OF AUSTRIA, CO-SPONSORED BY THE GOVERNMENT OF THE RUSSIAN FEDERATION AND THE GOVERNMENT OF THE UNITED STATES OF AMERICA, AND IN CO-OPERATION WITH THE EUROPEAN COMMISSION, THE EUROPEAN POLICE OFFICE, THE INTERNATIONAL CRIMINAL POLICE ORGANIZATION AND THE WORLD CUSTOMS ORGANIZATION

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2003

IAEA Library Cataloguing in Publication Data

International Conference on Security of Radioactive Sources (2003 : Vienna, Austria)

Security of radioactive sources : proceedings of an international conference held in Vienna, Austria, 10–13 March 2003 / organized by the International Atomic Energy Agency…[et al.]. — Vienna : The Agency, 2003.

p. ; 24 cm. — (Proceedings series, ISSN 0074–1884)

STI/PUB/1165

ISBN 92–0–107403–4

Includes bibliographical references.

1. Radioactive substances—Security measures—Congresses. I. International Atomic Energy Agency. II. Series: Proceedings Series (International Atomic Energy Agency).

IAEAL 03–00329

Printed by the IAEA in Austria
September 2003
STI/PUB/1165

FOREWORD

Radioactive sources are employed for beneficial purposes throughout the world, in industry, medicine, agriculture and research. Accidents involving radioactive sources and reports of illicit trafficking in radioactive materials have raised awareness of the safety and security risks created by sources that are outside effective control. The terrorist attacks of 11 September 2001 triggered international concern about the potential malevolent use of radioactive sources by terrorist groups.

In the early 1990s, the IAEA initiated a number of actions relating to the safety and security of high risk radioactive sources. In co-operation with five other international organizations, it established the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources and, to support the implementation of these Standards, launched a Model Project for upgrading radiation protection infrastructure in its Member States. More than 50 Member States participated in the early phase of this Model Project, and in recent years the number has increased to more than 80. In 1998, the IAEA, jointly with the European Commission, the International Criminal Police Organization and the World Customs Organization, organized an International Conference on the Safety of Radiation Sources and the Security of Radioactive Materials. The conference was held in Dijon, France, and was hosted by the Government of France. On the basis of the findings of that conference, an international Action Plan for the Safety and Security of Radiation Sources was developed; it was approved by the IAEA Board of Governors and endorsed by the IAEA General Conference in September 1999. An International Conference of National Regulatory Authorities with Competence in the Safety of Radiation Sources and the Security of Radioactive Materials, held by the IAEA and hosted by the Government of Argentina in Buenos Aires in 2000, produced findings that resulted in a revision of the Action Plan. In 2001, the IAEA held, in Stockholm, an International Conference on Measures to Prevent, Intercept and Respond to Illicit Uses of Nuclear Material and Radioactive Sources.

At the IAEA General Conference in September 2002, United States Secretary of Energy Spencer Abraham proposed, in the light of the concerns that emerged after 11 September 2001, the convening of an international conference to promote information exchange on, and raise governmental and public awareness of, key issues relating to the security of high risk radioactive sources, and to foster a better understanding of the measures necessary in order to improve the security of such sources and enhance preparedness for radiological emergencies. Many IAEA Member States and several international organizations responded positively to the proposal, and therefore the IAEA decided to organize an international conference on the security of radioactive sources in addition to its other activities in the field.

The International Conference on Security of Radioactive Sources took place from 10 to 13 March 2003 at the Hofburg Palace in Vienna. United States Secretary of Energy Abraham presided over the conference, which was co-sponsored by the Government of the Russian Federation and the Government of the United States of America and was hosted by the Government of Austria. The conference was organized by the IAEA in co-operation with the European Commission, the European Police Office, the International Criminal Police Organization and the World Customs Organization. It was attended by 751 participants and 28 observers from 123 countries and 12 organizations.

Opening addresses were given by the Director General of the IAEA, the Minister for Foreign Affairs of Austria, the President of the Conference, and representatives of the co-sponsors and the co-operating organizations. In an overview session, the speakers described the situation with regard to the security of radioactive sources worldwide and the perceived nature and extent of the threat of malevolent uses of such sources. Two topical sessions focused on the remedial measures necessary in order to deal with the situation and on measures for preventing the loss of control over radioactive sources. Four panel discussions addressed important aspects of the security of radioactive sources: interdicting illicit trafficking in radioactive materials; the roles and responsibilities of the various parties involved in ensuring the security of radioactive sources; planning responses to radiological emergencies; and the role of the media, public education, communication and outreach. All speakers and panel members had been invited by the Programme and Steering Committee. The presentations were followed by open discussions with broad participation from the floor.

The conference generated an exchange of information on key issues related to the security of radioactive sources, and it raised the awareness of governments of the risks associated with inadequate control of such sources and the need for urgent national actions by all States to minimize those risks. The conference emphasized in particular the need for an international initiative designed to facilitate the locating, recovering and securing of 'orphan' radioactive sources and the importance of effective national infrastructures for the safe and secure management of vulnerable and dangerous radioactive sources. In addition to these major findings, the conference resulted in a number of recommendations. The findings of the conference were brought to the attention of the IAEA Board of Governors at its March 2003 session.

These Proceedings contain the opening addresses, the invited papers presented during the overview and topical sessions and the panel discussions, and summaries of the discussions. The findings, as presented by the President of the Conference, and the closing remarks are also included.

The IAEA gratefully acknowledges the support and generous hospitality extended to the conference participants by the Government of Austria.

EDITORIAL NOTE

The Proceedings have been edited by the editorial staff of the IAEA to the extent considered necessary for the reader's assistance. The views expressed remain, however, the responsibility of the named authors or participants. In addition, the views are not necessarily those of the governments of the nominating Member States or of the nominating organizations.

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CONTENTS

IDENTIFYING, SEARCHING FOR, RECOVERING AND SECURING HIGH RISK, VULNERABLE RADIOACTIVE SOURCES (Topical Session 1)

STRENGTHENING LONG TERM CONTROL OVER RADIOACTIVE SOURCES (Topical Session 2)

INTERDICTING ILLICIT TRAFFICKING (Panel Discussion 1)

ROLES AND RESPONSIBILITIES (Panel Discussion 2)

PLANNING THE RESPONSE TO RADIOLOGICAL EMERGENCIES ARISING FROM THE MALEVOLENT USE OF SOURCES (Panel Discussion 3)

ROLE OF THE MEDIA, PUBLIC EDUCATION, COMMUNICATION AND OUTREACH (Panel Discussion 4)

CLOSING SESSION

ANNEX

OPENING SESSION

STATEMENT BY THE IAEA DIRECTOR GENERAL

M. ElBaradei
Director General,
International Atomic Energy Agency, Vienna

Overview

I am pleased to welcome you all to this conference on a subject that continues to generate serious public concern: the security of radioactive sources. Around the world, radioactive sources have been used for decades to benefit humankind — to diagnose and treat illnesses, to monitor oil wells and water aquifers, to preserve food and for many other purposes. Millions of sources have been distributed worldwide over the past 50 years, with hundreds of thousands currently in use. Most of these sources, such as those in smoke detectors, are weakly radioactive and individually pose little radiological risk. However, about 12 000 industrial radiography sources are supplied annually, and more than 10 000 medical radiotherapy units are in use. These types of sources — and others such as those contained in thermoelectric generators — are significant from a safety and security standpoint, because they contain potentially lethal quantities of radioactive material.

To protect the public from the hazards of ionizing radiation, cradle to grave control is essential for these radioactive sources. For many years the IAEA has been helping States to strengthen their national regulatory infrastructures, to ensure that such radioactive sources are appropriately regulated at all times. Until recently, our emphasis has been on the safety of radioactive sources, with source security as one aspect of safety. However, in the wake of the September 2001 terrorist attacks, and the stark awareness of the potential for radioactive sources to be used in malevolent acts, source security has taken on a new urgency. But while a number of countries are stepping up relevant security measures, many others lack the resources or the national infrastructures to effectively control radioactive sources.

Orphaned sources

A widespread problem involves sources that, owing to loss, theft or abandonment, have fallen outside official regulatory control — the ‘orphaned’ sources. This problem has been especially present in the Newly Independent States, where transitions in governments have in some cases led to a loss of regulatory oversight of radioactive sources.

In a large number of cases, even without malevolent intent, the loss of control over radioactive sources has resulted in death or serious injury. The well known incident in Goiânia, Brazil, in the 1980s, is frequently cited as an example. This was a case in which the inadvertent dismantling of a radiotherapy source and the dispersal of ^{137}Cs resulted in a number of fatalities and significant social and economic disruption.

Many factors can lead to a loss of control over radioactive sources, including: ineffective regulations and regulatory oversight; a lack of management commitment or worker training; poor source design; poor physical protection of sources during storage, transport and use; abandonment due to economic factors; and theft or other malevolent acts. In view of this wide range of possible causes, addressing the problem is a difficult and complex challenge.

Radiological terrorism

As I just mentioned, after the events of September 2001, issues related to terrorist activities — including nuclear and radiological terrorism — were catapulted into the spotlight. Given the apparent readiness of terrorists to disregard their own safety, the personal danger from handling powerful radioactive sources can no longer be seen as an effective deterrent. This awareness prompted a thorough re-evaluation of the risks involved. In view of recent reports about terrorist plans to build and deploy radiological dispersion devices — and given the inadequacy of source controls I just mentioned — it is clear that additional security measures are urgently needed. This concern has been the focus of the international community in the past 18 months. I trust that this conference will help to identify what has been accomplished and to focus on additional measures that need to be taken to cope with the challenge.

Clearly the use of a radiological dispersion device — sometimes referred to as a ‘dirty bomb’ — will, as with any explosion, kill or injure people through the blast. But the most severe impacts of a dirty bomb would probably be the panic and social disruption associated with exposure to radiation, the very purpose of an act of ‘terror’.

IAEA activities

The IAEA and its Member States have been hard at work to raise the levels of radiation safety and security associated with radioactive sources, focusing on countries with urgent needs. Nearly a decade ago, the IAEA established the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, and recently the

IAEA has used a Model Project on Upgrading Radiation Protection Infrastructure to help Member States establish the infrastructure to improve their control of radioactive sources. Both the Basic Safety Standards and the Model Project have included specific aspects related to source security as well as safety, but in many countries these requirements have not been implemented, with the result that the regulatory control of radioactive sources remains weak, and the States' inventories of such sources are not well maintained.

The IAEA has also developed a Code of Conduct on the Safety and Security of Radioactive Sources, a Categorization of Radioactive Sources and an international database on radiation events (RADEV). In addition, it has sponsored a number of relevant international conferences, which made specific recommendations for creating national source registries, securing orphaned sources, and preventing criminal misuse involving nuclear and other radioactive materials.

But the most direct impact of IAEA activities in this area has come in actual field work: that is, assistance to States to meet urgent needs or to provide the training, equipment and expert advice to raise the level of performance in the area of source security — including assistance through the IAEA's appraisal service for evaluating a State's radiation safety regulatory infrastructure.

In a number of cases, the IAEA has lent its expertise to locate and secure orphaned sources. In Kabul, Afghanistan, last year, the IAEA helped to secure an abandoned powerful cobalt source. In Uganda a week later, it helped the Government to secure a source that appeared to have been stolen for illicit resale. And a Georgian team supported by the IAEA successfully recovered two powerful radioactive sources that had been left unshielded and unsecured.

Similar problems with orphaned sources exist in other countries. Recently, a tripartite initiative was established by the IAEA, the United States Department of Energy (DOE) and the Ministry of the Russian Federation for Atomic Energy (Minatom) — in an effort led by Secretary Abraham and Minister Rumyantsev — to locate, recover, secure and recycle orphaned sources throughout the countries of the former Soviet Union. Two joint missions were carried out in the Republic of Moldova and Tajikistan last year, and more are planned for this year; however, no similar arrangement is available yet to help countries outside the former Soviet Union.

Another area of IAEA focus is on illicit trafficking and the potential malevolent use of sources. The IAEA's Illicit Trafficking Database includes over 280 confirmed incidents since 1993 involving radioactive sources. The actual number of cases may well be significantly larger than the number reported to the IAEA. Customs officials, border guards and police forces continue to detect numerous attempts to smuggle and sell stolen sources.

The IAEA has been actively assisting States to strengthen their border controls against illicit trafficking and to improve their physical protection of radioactive sources. Recent examples include: workshops on border monitoring and illicit trafficking held in Vladivostok and St. Petersburg for customs and law enforcement officials from the Newly Independent States; a workshop on border monitoring for law enforcement officials in the Philippines; a meeting in Ghana to plan assistance to African States on the full range of nuclear security issues; and incident related advisory missions to Bolivia, Nigeria and the United Republic of Tanzania on issues related to illicit trafficking.

Looking to the future, it is clear that much remains to be done to improve the security of radioactive sources worldwide. The IAEA will remain actively engaged in assisting States to search for, recover and secure orphaned sources, and to improve their own national measures for the control of radioactive sources.

This conference

Before closing, I would like to acknowledge with gratitude the leadership shown by the US Secretary of Energy, Spencer Abraham, in continuing to highlight the urgency of addressing the security of radioactive sources worldwide. It was Secretary Abraham, during the September 2002 session of the IAEA General Conference, who suggested the need for our present conference.

The IAEA is grateful to the Government of Austria for hosting this conference, to the Governments of the Russian Federation and the United States of America for sponsoring the conference, and for the co-operation of the European Commission, the European Police Office, the International Criminal Police Organization and the World Customs Organization. The control of radioactive sources is one among several areas of expanding IAEA activity, and the IAEA will need broad support from all its Member States, including financial support, to ensure that we deal effectively with this imminent danger. Naturally, the success of this conference will be measured by our success in agreeing and implementing the necessary measures to protect ourselves against any malicious use of radioactive sources. I wish you every success in your discussions.

STATEMENT BY THE AUSTRIAN FEDERAL MINISTER FOR FOREIGN AFFAIRS

B. Ferrero-Waldner
Federal Minister for Foreign Affairs, Vienna, Austria

It gives me great pleasure to welcome you here at the Vienna Hofburg, the former imperial palace and venue of many important conferences in the past. As host of this important conference, I hope that despite your intensive programme, you will find some time to enjoy the hospitality of the city of Vienna.

The elegance of the Hofburg stands in stark contrast to the topic which you will discuss in great detail during the next three days. The terrorist attacks of 11 September 2001 have alerted the world to the potential of nuclear terrorism. Today the world finds itself on the brink of a war over the issue of weapons of mass destruction.

The caves of Tora Bora, of all places, have revealed how close terror networks may have come to producing crude radiological dispersal devices, commonly referred to as 'dirty bombs'. Although the destructiveness of dirty bombs in terms of loss of life and injuries is much smaller than in the case of a nuclear explosion, it would still be horrendous. It would also create enormous panic and chaos among the population and have severe psychological effects. The costs of a wide scale evacuation of the affected population, the subsequent cleanup of contaminated property and the long term health hazards would be considerable.

It is, of course, impossible to accurately assess the likelihood of an attack with dirty bombs. But precisely for this reason a cradle to grave control of powerful radioactive sources is urgently needed to protect them against terrorist acts, theft or mishandling. The high number of accidental contaminations with radioactive material in the past two decades points in the same direction.

As the IAEA has repeatedly pointed out, millions of radioactive sources have been distributed worldwide over the past 50 years and are used to benefit humankind in a wide range of medical, agricultural, industrial and research applications. The security of radioactive materials has traditionally been relatively light. Hence there is a clear need to strengthen existing security measures as well as to identify and implement additional measures against the potential malevolent use or accidental misuse of radioactive sources.

As radiation knows no boundaries, the security of radioactive sources is a legitimate concern of all States. Thus countries must demonstrate to their own citizens as well as to the international community that strong and effective security systems are in place and that the dangers stemming from terrorists who are determined to wreak havoc on the civilized world are not being underestimated. It is by the security we provide that we as governments will be judged by our citizens.

This conference is important, because it can — and I quote from the mandate of the conference — “help foster a better understanding of the nature of the threats of potential malevolent use, on ways to diminish the likelihood of such threats occurring, and of the necessary measures for preparedness and response in case they do occur.”

In this context, I should like to take this opportunity to commend Director General Mohamed ElBaradei and his team for their intensive hard work in the past several years in serving as a catalyst for the efforts of many governments to address the challenge posed by radioactive sources and in particular to prevent and counter nuclear terrorism. As we all know, the IAEA has offered and continues to offer a wide variety of services to governments to that end, ranging from assistance in locating, securing and disposing of powerful radioactive sources, to the provision of equipment and the training of border guards and other law enforcement officials. I am confident that the IAEA’s impressive expertise will stimulate and enrich our discussion.

More than ever before the IAEA is at the centre of world attention in its efforts to prevent nuclear proliferation at a juncture in history where this pressing issue dominates the international agenda. The IAEA as well as the other United Nations organizations in Vienna play an invaluable role in helping the UN and in particular the Security Council to fulfil their responsibility for maintaining world peace in the face of the new dangers of terror and weapons of mass destruction.

Finally, I am pleased to note that it is not only the number of participants that exceeds all our expectations, but also the level of participation. This attendance testifies to the importance many countries attach to the security of radioactive sources and to this conference. I have no doubt that this combination of political decision makers and experts will make the conference very successful. I wish you an inspiring, vivacious debate and — even more importantly — fruitful results of your work.

REMARKS BY THE PRESIDENT OF THE CONFERENCE, THE UNITED STATES SECRETARY OF ENERGY

S. Abraham
Secretary of Energy,
Washington, D.C.,
United States of America

It is an honour and a pleasure to be here to address this conference, both as its President and on behalf of my Government. I want to begin by thanking Director General ElBaradei for his gracious welcome, and for all the work he and his staff, including Abel González, have done to make this conference possible. I also want to express my appreciation to the Russian Federation, co-sponsor with the USA of the conference, and in particular to Minister of Atomic Energy Rumyantsev. Thanks also to Minister Ferrero-Waldner for welcoming us all to the wonderful city of Vienna. And thanks to all of you here today for attending this important conference.

We are gathered here to deal with an important issue: the terrible threat posed by those who would turn beneficial radioactive sources into deadly weapons. The technical term for these weapons — radiological dispersal devices, or RDDs — has not come into general use. I seldom see it in a headline, or hear it in a newscast. But increasingly the public knows about these weapons, and they are deeply concerned. They call RDDs 'dirty bombs'.

It is our critically important job to deny terrorists the radioactive sources they need to construct such weapons. The threat demands a determined and comprehensive international response. Our governments must act, individually and collectively, to identify all the high risk radioactive sources that are being used and that have been abandoned. We must educate our officials and the general populace, raising awareness of the existence of these dangerous radioactive sources and the consequences of their misuse. And we must account for and tightly secure these sources wherever they may be. Radioactive sources can be found all over the world, and terrorists are seeking to acquire them.

The threat they represent to people of every nation is very real. This threat has been a particular concern to the USA since the September 11 attacks. On that day, we learned that terrorists will strike anywhere, at any time. They will employ technology never intended for use as weapons, to murder thousands of innocent and unsuspecting people in the most shocking and ruthless way. We know now that there is no weapon they will not use, and no weapon they are not seeking to acquire. There is nothing they would like better than to cause the panic that the detonation of an RDD would create.

We know from experience with accidental releases of radiological sources that they can cause widespread panic, economic hardship and significant health concerns. Remember Brazil, in 1987. Urban scavengers found a medical teletherapy machine left in an abandoned building. They removed the radioactive source from its shielding, ruptured it and distributed the beautiful blue, glowing powder they found inside to their friends, neighbours and relatives. The powder was ^{137}Cs. Four people died. More than 110 000 people were monitored for radiation exposure at the city's sports stadium. Scores of buildings were evacuated and some were even demolished. Cleanup costs were enormous. The incident generated about 3500 cubic metres of radioactive waste. Actual fatalities were relatively light in the Brazil incident, but panic was widespread. I can only imagine how much worse the situation would have been had terrorists dispersed the toxic material rather than innocent, uninformed people.

That's why our work is so important. It is our responsibility to determine how to prevent such an attack in the first place, and how we should respond if, despite our best efforts, such an attack were to occur. All countries should act in their own self-interest by taking the steps needed to better secure high risk radioactive sources.

I came here to Vienna for the IAEA's 45th General Conference just six days after September 11. At that time, I called on the IAEA's Member States to confront the new terrorist threat. The IAEA Secretariat proposed, and the Board of Governors approved, a new Nuclear Security Fund to help Member States to protect against nuclear terrorism. The action plan covers a broad range of activities to help States put in place the legal, regulatory and technical elements needed to reduce the risk of misuse of nuclear and other radioactive material. Thus far, the USA has contributed US $8.7 million to the IAEA programme. I encourage all Member States to contribute to this fund. Last September, at the 46th IAEA General Conference, I discussed the reasons why RDDs presented a growing and disconcerting threat of a new kind. In my remarks then, I proposed that this conference be convened.

My reason for suggesting the conference was in no small measure because RDDs are different from what we are accustomed to in our more traditional nuclear non-proliferation work. We are used to policing a defined number of nuclear facilities. Our job has been to focus on that small number of countries bent on violating the nuclear non-proliferation norm and acquiring fissile materials for nuclear weapons. But the radiological materials that could be used in an RDD exist in a variety of forms in virtually every country in the world. And they are often only loosely monitored and secured, if at all.

The use of radioactive sources is widespread. They have many beneficial industrial, agricultural, research and medical applications. In the medical field alone, roughly one hundred radioisotopes are used in various nuclear medical research, diagnostic, sterilization and teletherapy applications. Millions of cancer patients have had their lives prolonged owing to radiotherapy treatments, and patients of all kinds have benefited from bacteria-free, sterile medical equipment made possible by irradiation technology. Many more lives have been saved thanks to the smoke alarms and emergency exit signs that are now common in homes, schools and offices.

Scientific research using radioactive materials takes place in laboratories all over the world. Radioisotope thermoelectric generators, or RTGs, have been used for remote power application. Industrial gauges containing radioactive sources are commonplace. Radiation is used to increase the size and improve the health of crops, and remote beacons stand sentinel for years thanks to radiation's energy.

Despite the wide use of radioactive sources, only a small portion of them pose a real threat as potential ingredients in an RDD. I called for this conference last September in order to raise awareness of those radiological materials that have the greatest potential to result in exposure, contamination and mass disruption. Your presence here — almost 600 participants from well over 100 countries — is reassuring proof of how seriously we all take the RDD threat.

I have said on many occasions — before the IAEA and elsewhere — that taking measures to control dangerous and vulnerable radioactive sources is the responsibility not just of a few nations, but of all nations. Each of us must act to create a seamless web of protection and control of high risk radioactive sources to prevent their malevolent use. Each of us must take on this significant responsibility.

In the USA, we are evaluating potential vulnerabilities in our control of these materials in order to strengthen our regulatory infrastructure to better account for them, to track their use and disposition, and to ensure appropriate protection during import and export. We are also working to ensure that those using these radioactive sources are authorized to do so and are using them for legitimate purposes.

In determining what additional protective measures might be needed, we are using a graded approach that takes into account potential hazards and the protective measures already in place. These actions will ensure that the sources that are of greatest concern do not fall out of regulatory control and become orphaned in the future.

In short, we are taking action to lessen the threat of radioactive sources being misused in an RDD. I would like to ask everyone here today, the government representatives and officials in a position to take bold and decisive action, to do the same. Collectively, we can all make a difference. Collectively, we can all reduce the threat of RDDs worldwide. We can all work at home and through the IAEA to get the job done.

The USA believes that to solve the problems we will discuss today, we must attack them in all their dimensions. That's why I am pleased to announce today a new initiative that I hope will become international in scale. The Radiological Security Partnership is a three pronged approach to addressing the potential threats from undersecured, high risk radioactive sources.

The first prong is helping countries accelerate and expand national initiatives to keep track of and better secure national inventories of high risk radioactive sources. In this regard, our new partnership includes a new initiative to provide well over $1 million in technical assistance and equipment to IAEA Member States to facilitate effective tracking of high risk sources. We are ready to assist other interested countries to speed the needed improvements, and we want to begin immediately.

Second, countries need to draw on international resources that can give practical advice and assistance in bringing these sources under control. The USA is currently working with the Russian Federation and the IAEA to identify and secure high risk radioactive sources in the territories of the former Soviet Union, and we believe the time has come to broaden that kind of co-operation. To do so, I am pleased to announce a new US initiative to expand this 'Tripartite' model to other countries in need of assistance. It is my hope that this model, which is working so well in the territories of the former Soviet Union, will become global in scale.

The USA will focus its resources where the need is greatest. Our emphasis will be on developing countries. We are prepared to work with other countries to locate, consolidate, secure and dispose of high risk, orphan radiological sources by developing a system of national and regional repositories to consolidate and securely store these sources.

The international efforts to choke off the illicit traffic in these sources must also be given highest priority. As I mentioned earlier, the USA is committed to establishing detection choke points at suspected smuggling routes, in order to better detect illicit traffic in radioactive sources.

I recently initiated a new US Department of Energy (DOE) project to improve our ability to detect nuclear materials or weapons en route to the USA. As the third prong of our plan, I will now expand this project by focusing on other major transit and shipping hubs, which will improve our efforts to interdict and prevent illicit trafficking in high risk radioactive sources globally.

I am also pleased to announce that next week members of the DOE will participate with the IAEA in important consultations that will set technical specifications for border monitoring equipment. This equipment, which in some cases can be as simple and small as the radiation pager I'm holding in my hand, can play a key role in the effectiveness of this critical initiative. By working together on all these dimensions of the threat, we have a chance to make rapid and significant progress towards our shared objective of reducing the potential threats from the highest risk sources. The Radiological Security Partnership is a US priority. To demonstrate our commitment, the USA plans to contribute $3 million over the next year to support the Partnership. In particular, this money will support our efforts to work with governments of developing countries to secure high risk sources in their countries. Later this morning, Mr. David Huizenga of the DOE will discuss elements of our strategy in greater detail, and all that the US Government is doing to execute it.

Having outlined what my Government has done and is willing to do, I want to applaud the work that has already been done by the IAEA and by other Member States. While this may be the largest conference held on the security of radioactive sources, it is not the first. I am thinking particularly of the 1998 conference in Dijon, which was one of the first to deal with the security aspects of radiological sources. The IAEA Member States are developing a revised Code of Conduct to guide their efforts to better account for undersecured radioactive sources. I understand the drafting work on the Code is just about completed, and I applaud the Member States for making the Herculean effort this task required. I urge all Member States to review the Code before it comes to the Board of Governors for approval. The USA strongly endorses this process.

The IAEA is taking important steps to categorize radioactive sources so that the international community better understands which sources pose the greatest security risks. It is also carrying out its Model Project to help Member States improve their national infrastructures and regulatory systems of control. The IAEA is taking concrete steps in the Republic of Moldova and elsewhere to secure at-risk radiological sources, and is helping countries establish effective systems for tracking and inventorying these sources.

We have already demonstrated our ability to address these problems. For example, the Republic of Georgia, in co-operation with the IAEA, undertook the dangerous task of recovering RTGs that had been left unprotected in the countryside. Thanks to the commitment of the Georgians, the IAEA and even my own agency, the RTGs were secured in record time. The Georgians, in co-operation with the DOE, were also able to upgrade the security of the facility where the RTGs were stored.

I have outlined a number of steps that the USA is taking, and I have noted steps that the IAEA has initiated that can truly benefit the international community's ability to get a handle on these problems. I know many of you have also taken important steps, and we will all benefit from your knowledge and experience as we each strive to establish ‘best practices and procedures’ and come to grips with the challenges presented by radiological sources. That is why this conference is important — it will help all of us to establish a framework for addressing these issues, and to take the critical next steps to protect our citizens and provide for our security.

We have a great deal of work to do over the next three days, and a tremendous amount of information to share. We will be hearing from experts from around the world, and we will hear from those who have had to deal with radioactive source problems first-hand. It is my hope and expectation that, as a result of our intensive and wide ranging discussions, we will reach a consensus on steps that can be taken to ensure that IAEA assistance and other resources are made available to all nations. When we leave this conference, we will have a few essential steps to take to begin to ensure the security of our nations' — and the world's — radioactive sources:

— We must all identify the high risk radioactive sources in our countries and ensure that they are under secure and regulated control.
— We must determine the criteria we will use to identify the radioactive sources that provide the greatest threat to security, so that nations can establish effective regulatory infrastructures.
— We must assess the security of our borders, and further improve our ability to prevent the illicit transit of radiological sources.
— And we must know realistically just how prepared we are to respond, in the case of an actual emergency involving these sources.

There is much work ahead for all of us, and this conference is the place to start. I hope that historians will someday write that our deliberations signalled a turning point — that on March 11, 2003, we began to forge an international consensus on the need to deal urgently and decisively with the most dangerous and vulnerable radioactive source threats. Thank you very much. We look forward to a successful conference.

REMARKS BY THE MINISTER OF THE RUSSIAN FEDERATION FOR ATOMIC ENERGY

A.Yu. Rumyantsev
Minister of the Russian Federation for Atomic Energy,
Moscow, Russian Federation

The urgency of the issue to be discussed in the framework of this conference is obvious. Despite the fact that the history of the development and use of radioisotope products is just a little over 50 years of age, the range of present applications is quite diverse. They cover industry and power production, metallurgy and geology, mining and the environment, meteorology and agriculture, and the chemical, oil and gas industries.

I would like also to mention separately one more field of use of isotope products, which is medicine. Wide use is made of radioactive substances and other ionization sources for diagnostics, medical treatment and research purposes. Radioisotope methods are widely used in diagnostics and therapy. They are most efficient in evaluating structural and functional changes of different organs. Thus the list of radiopharmaceuticals used in medicine is getting longer every day.

It is obvious that the range and field of use of different radionuclide sources in contemporary life are expanding: radionuclide sources of electric power (radioisotope thermoelectric generators, or RTGs); autonomous power supplies for various kinds of equipment in remote and difficult to reach areas (radio and light beacons, meteorological stations); radiation technological units for the sterilization of medical products, and the processing of agricultural products and industrial and domestic waste; equipment for actinotherapy; different devices for the control of technological processes (measurement of density, level and thickness); and devices for non-destructive control (gamma defect detectors) and for analysing the content of materials.

It goes without saying that the issue of safe and secure management of these kinds of products throughout their life cycle, beginning with their manufacture and up to their disposal, remains a key issue.

The Russian Federation, as one of the major manufacturers and consumers, as well as an exporter and importer, of ionizing radiation sources, has always taken great care with all the safety and security aspects of managing this kind of product. The same is true of the former Soviet Union. This attention to safety and security arises from a developed legal base, including provision for action against the illegal purchase, storage, use, transfer or destruction of radioactive materials.

The licensing of activities in the field of radioactive substance management stands in the way of uncontrolled proliferation of radioactive substances and radiation sources. The licence holder is obliged, among other things, to properly dispose of radioactive substances which are of no further use, to be accountable for the control, safe storage and physical protection of radiation sources, etc.

At the same time, in discussing the issue of the safe and secure use of isotope products in the 'global' sense, we must admit the obvious: this is an issue of urgency for a number of reasons.

One reason is the threat posed by different terrorist organizations in the world, and another the disintegration of the former Soviet Union that led to a loss of control over sources, and in some cases to the loss of sources as such. An example is the unauthorized opening of RTGs by members of the local populations in Kazakhstan and Georgia to obtain non-ferrous metals. For some, the dose that they were exposed to turned out to be too high.

In addition, after the break-up of the former Soviet Union, new government control systems for the location and transport of radioactive and nuclear materials in the separate independent States had to be developed afresh, which allowed an opportunity for a variety of unprecedented criminal offences, including those with radioactive sources.

Growing terrorism also led the world community to re-evaluate the threat of the use of biological, chemical and radiological materials by different terrorist organizations, religious extremists and criminals. As a direct result, a tripartite initiative (Russian Federation–USA–IAEA) to increase the level of safety and security of radioactive sources was established. Its purpose is to develop appropriate control over used sources, as well as to search for, remove and convert to a safe condition orphaned sources on the territory of the Commonwealth of Independent States.

The level of risk connected with the use of radioactive materials can be estimated in terms of the threats of acts of radiological terrorism and thefts of radioactive materials. However, at present there is no proof and there are no complete data on illegal trafficking of radioactive materials or on cases of 'radioactive blackmail'. According to IAEA information, since 1993, 201 cases of illegal sale of radioactive sources have been registered, including sources used in medicine and industry.

The world is concerned and wishes to protect itself. Understanding this requires the consolidation of efforts in the field of international co-operation that we are discussing today. The strategy of joint action against attempted acts of radiological terrorism obviously needs to be based on systematic analysis of all the aspects of the safe use of radioactive sources, as well as a critical review of the experience accumulated by the world community in non-proliferation. All this can be and must be taken into account when setting up international and national safety systems for the use of radioactive sources and for effective response systems against radiological terrorism.

Illegal trafficking of ionizing radiation sources can pose a threat to national security, public health and the global environment. All this requires us to expand collaboration and strengthen international co-operation with regard to cross-border traffic of radioactive materials, the operation of highly hazardous radiation units, the exchange of information between States and international organizations and the updating of antiterrorist laws.

As for national systems, those are to be based, in the first place, on the adherence to and respect for international agreements and conventions, as well as national legislature. Radioactive materials management must include accountability, licensing and issuing of special permits for activities involving radiation sources; control over export–import operations; and the involvement of law enforcement agencies, intelligence and border control. A number of States are facing the urgent issue of creating a legal basis that would regulate the use, location and disposal of radioactive sources. The safe use of sources and a guarantee of their safety can be secured only by having legal and technical documentation, including international conventions and precise instructions to consumers on the registration of the sources and their further management. The IAEA has accumulated positive experience in consolidating international efforts and supporting the development of legal instruments on different aspects of the use of nuclear energy for peaceful purposes. Taking this into account, the IAEA's key role in assisting Member States with regard to setting up national infrastructures for the management of potentially hazardous radioactive sources is incontestable.

Appropriate attention must be focused on the development of a set of measures to eliminate the consequences of possible terrorist acts involving the use of devices based on radioactive sources. I believe that the response system being developed must minimize not only the direct radiological consequences, but also the indirect psychological, medical, social and economic consequences. Our tragic experience of a large scale accident illustrates the fact that society is extremely sensitive to any radiation risks and is prone to various phobias, foremost among them radiophobia.

Phobias are caused by a lack of knowledge or by plain ignorance. Ignorance is caused by a lack of curiosity and by laziness. Hardly anyone among non-professionals will go to a library to read the contemporary literature on radiology. It is much easier to read a biased newspaper article. Specialists in psychology believe that phobias are contagious, and that it is possible, through manipulation, to create a negative impact on the health of a lot of people. And here I would like to touch upon another important issue directly linked to the issue of the safe and secure use of ionizing radiation sources.

The attitude to radiation ought to be characterized by vigilance in response to real danger, and much depends on information supply and awareness. To exaggerate the threat of radiological terrorism may also have a negative impact on the scale of use of irradiation sources.

When the population receives minimal information but hears plenty of rumours, and as a result develops superstitions, then, on the one hand, we get radiophobia, and on the other, irresponsible behaviour. What we need is a large scale, civilized information system for society on all the range of issues concerning the safe use of ionizing radiation sources, which will help to preclude the possibility of their unauthorized use.

The way to do this is traditional: it involves the mass media, i.e. press, radio and TV; the introduction of specialized educational programmes in schools and colleges; and round tables with the participation of community representatives, scientists, industry people, etc. This issue must be addressed by involving international organizations, such as the IAEA and the World Health Organization, as well as national institutions such as academies of science.

Our idea of the scale and possible consequences of radiological terrorism defines the priorities and the efforts that are undertaken today for the purpose of increased safety in using radionuclide sources in the Russian Federation. The first steps in this direction are being taken in the framework of agreements between the US Department of Energy and the Ministry of the Russian Federation for Atomic Energy.

I believe that it will be no mistake to express my confidence in this conference, organized by the IAEA, the US and Russian Governments, and a number of other international organizations. I am sure that it is just the beginning of a fruitful international co-operation in this field, as well as a strong stimulus for everyone.

PRESENTATION BY THE INTERNATIONAL CRIMINAL POLICE ORGANIZATION

D. Powers
Public Safety and Terrorism Sub-Directorate,
International Criminal Police Organization, Lyon

The International Criminal Police Organization (ICPO-Interpol) is the only global police organization. Created in 1923, it currently has 181 Member States. Interpol's General Secretariat has its headquarters in Lyon, France, and is the central operational body of the organization. It is comprised of over four hundred employees whose primary duty is to provide a neutral and central site for the exchange of key police information relating particularly to transnational criminal activity.

With respect to the particular emphasis of this conference, Interpol has managed a series of initiatives in support of the fight against international illicit trafficking in radioactive materials. Among these initiatives was the creation of working groups to discuss this subject in a search for the best practices in prevention, identification and investigation of trafficking in these materials. As a result, several key issues were identified as essential to making international co-operation both more efficient and more effective.

First, the multiagency approach. Interpol recognizes the importance of maintaining a programme of joint initiatives between law enforcement, the IAEA and the World Customs Organization (WCO). Police officers, together with customs officials and nuclear regulatory authorities, have been participating in relevant training courses, meetings, conferences and seminars co-sponsored by Interpol and the WCO and organized by the IAEA. Another result of these joint initiatives are the three recently published technical documents on preventing, detecting and responding to events involving the trafficking in or criminal use of radioactive materials.

Second, standardized international co-operation. We are continuing our efforts to promote the exchange of relevant information among the different databases that belong to various international organizations in this field. This co-operation also includes the consistent reporting of serious incidents by the responsible agencies within the Member States to their corresponding international organizations. It is only with standard and regular global reporting that we can ensure the most accurate crime mapping of this problem. And it is only with an accurate mapping of the problem that together we can design the most effective responses globally, regionally and nationally.

Finally, training of enforcement officers. Training courses are of capital importance. In order to be highly effective in confronting the smuggling of radioactive material, we should be as technically proficient as possible, at the national as well as the international level.

It is understood that each international organization has a different point of view of the problem and a different way of dealing with it within the scope of its particular purpose, mandate or capabilities. However, these multiagency forums act as a force multiplier and constitute a unique and dynamic platform to confront the problem.

Apart from the efforts made by police and customs officials in identifying and preventing the use of weapons of mass destruction by terrorists, the IAEA has been very successful through its actions in helping to prevent the loss of control over radioactive material. However, as the terrorist threat remains significant, we must continue our vigilance. Effective preventive measures have been undertaken and the IAEA has played an outstanding role in this connection.

Whether it be through use of our 24 hour command centre, our vast criminal intelligence database, our ability to gather and disseminate focused analytical criminal data to our Member States, or our ongoing training programme, Interpol is uniquely positioned to positively contribute to law enforcement efforts in combating the threatened or actual malevolent use of radioactive materials. Interpol very much appreciates the close working relationship that has been developed over the years with the various institutions represented here today. Interpol assures you of its future co-operation in this endeavour.

ROLE OF CUSTOMS IN SECURITY AND FACILITATION

R. Mellwig
Deputy Director, Compliance and Facilitation,
World Customs Organization, Brussels

The World Customs Organization (WCO) is an intergovernmental organization representing 161 customs administrations worldwide. In June 2002 the membership of the WCO passed the Resolution on Security and Facilitation of the International Trade Supply Chain. This Resolution represents a new dimension for governments and their customs administrations. Every country is now faced with the challenge of protecting its national territory from acts of terrorism and organized crime while making every effort to facilitate legitimate trade. This initiative, which is supported by the G8 countries, the International Maritime Organization, the IAEA, the International Chamber of Commerce, the International Criminal Police Organization, the World Shipping Council, the International Chamber of Shipping and many other international bodies, is helping to safeguard national territories and create a new international framework for safe and secure international trade. As part of this process, customs administrations must be recognized as being one of the key agencies, since their special competence at the frontier is needed in managing the risks relating to passengers and freight moving internationally.

National legislative reforms covering specific antiterrorism legislation, advance passenger/cargo information, organized crime and money laundering are being pursued by the governments of our Members. The WCO administers international conventions, guidelines and best practice models for use by governments when drafting or reviewing legislation.

Existing procedures developed by the WCO that are being adapted to take into account antiterrorism requirements include:

— *Revised WCO Kyoto Convention*. Provides an international standard and framework for customs procedures applying risk management.
— *WCO Customs Data Model and Unique Consignment Reference*. Provides a world standard for transmitting, tracking and tracing consignments.
— *WCO Guidelines for Advance Passenger Information*. Assists in the management of risks associated with the movement of air passengers.

— *A modern multilateral instrument on mutual administrative assistance*. Provides the legal basis for administrative assistance between customs administrations and the sharing of information for security screening.

Moving to the area of specific co-operation between the WCO and the IAEA, I would like to point out that the two organizations have been in close co-operation since 1995. The partnership was formalized by the signing of a Memorandum of Understanding in 1998. The two organizations have jointly developed a number of initiatives:

— A WCO Council Recommendation concerning action against illicit cross-border movement of nuclear and hazardous material was concluded in June 1997.
— At the operational level, the Customs Enforcement Network (CEN) global database now has a separate recordation for nuclear and hazardous materials. A number of significant seizures have been reported and 'alerts' disseminated globally.
— Training material and an Enforcement Module on Nuclear and other Radioactive Materials have been developed for customs trainers.
— Training courses covering the technical aspects of the subject have been delivered.

The WCO Secretariat will continue to provide technical assistance and training in line with the availability of its human resources. We will continue to co-operate with the IAEA and other relevant international organizations. I thank the organizers for inviting the WCO to take part in this important meeting. We are honoured to be one of the co-operating organizations of this initiative. I wish the meeting every success.

PRESENTATION BY THE EUROPEAN COMMISSION

F. De Esteban
Directorate General for Energy and Transport,
European Commission, Brussels

The European Commission considers the organization of this international conference to be an excellent initiative, given that both the safety and the security of radioactive sources are an ongoing concern for the European Union.

In our Member States, the use of radioactive sources is subject to the requirements set out by the radiation protection legislation adopted pursuant to Chapter III of the Euratom Treaty. That the Commission's approach to enhancing safety in the Union is fully in line with the Euratom Treaty was supported by the recent European Court of Justice decision that radiation protection cannot be separated from the safety of sources of radioactivity.

The Commission has carried out several actions aimed at minimizing the risk to the public as well as to the environment arising from the use of radioactive sources.

Within the framework of its activities in the field of radioactive waste management, the Commission published in 2000 a study on the management and disposal of disused sealed radioactive sources. The report estimated that approximately 500 000 sealed sources have been supplied during the past 50 years to operators in the Union's current 15 Member States. Of these 500 000 sources, approximately 110 000 are currently in use.

The risks associated with the planned use of these sources are well known, and regulations can be laid down. However, actions directed to malevolent uses can, unfortunately, still occur. Only strict control will increase the security of radioactive sources. The sources at greatest risk of being lost from regulatory control are disused sources held in local storage at the users' premises, waiting for final disposal or return to the manufacturer. The study estimates that there are about 30 000 such sources throughout the present European Union. This number is expected to increase with the forthcoming enlargement. Consequently, the attention of the Commission is particularly focused on sources over which, for various reasons, control has been lost. These orphan sources present an important risk. Several accidents or incidents involving them occur every year around the world.

In some instances, national authorities have to deal with cases of inadequate management of sources, which lead to some sources being lost to regulatory control. Also, in spite of the system of detection implemented, recurrent incidents regrettably occur in industries where scrap metal is recycled, though such incidents are now less common than in the recent past. However, the accident in Spain in May 1998 gave an important impetus to efforts in this area and resulted in requests from some Member States for specific European Union legislation.

Recently the Commission adopted a new Directive that will cover the most dangerous of these sources. In particular, the Directive will require a number of authorizations and a recording of sources, and most importantly, will place a number of obligations on the holders of sources, such as rigorous source tracking and user training. The Directive will also require the return or transfer of disused sources to a supplier or to a recognized installation. This requirement is particularly important from the point of view of security in the short to medium term. We hope that the European Council will soon adopt the Commission's proposal.

Concerning security in the longer term, it is very important to have a disposal route for many of these sources. Of particular interest here is another proposal for a Commission Directive requiring Member States to establish firm plans for radioactive waste management. A key element of this Directive is a timetable for identification and authorization of operation of disposal sites.

In summary, the Commission places great importance on the safety and security of radioactive sources. Existing Community legislation already helps to ensure this, but new proposed legislation will be a major step forward in guaranteeing such safety and security in the future.

In the Commission, we are working on the construction of an area of peace, prosperity and stability. This is the essential objective of the European Union. But our work needs a solid network of co-operation with all other countries and with international organizations. We are ready to work closely with all others at this conference to identify common solutions to the problems posed.

I hope that the conference will achieve its intended purpose and will provide the expected result of greater security of radioactive sources worldwide.

OVERVIEW SESSION

PREVENTING THE RADIOLOGICAL DISPERSAL DEVICE

A. NILSSON
Department of Nuclear Safety and Security,
International Atomic Energy Agency,
Vienna
E-mail: a.nilsson@iaea.org

Abstract

The paper discusses the IAEA plan of action to protect against nuclear terrorism, the nature of the threat of a radiological dispersal device, international instruments for the prevention of nuclear terrorism, recent progress and perspectives for future action.

1. BACKGROUND

Nuclear security is not a new subject. It started with the awareness that nuclear material, if coming into the wrong hands, could be used in nuclear explosive devices, and it has given rise to countermeasures such as nuclear material control and physical protection. For other radioactive materials, including sources, the traditional approach has been to consider security as an integral part of safety, i.e. for the radiation protection of workers and for public safety. The events of 11 September 2001 triggered a reconsideration of the risks for, and consequences of, terrorist acts involving nuclear or other radioactive materials. The dangers of radiological dispersal devices (RDDs) were recognized.

In addition to records of past events in which there was a threat or risk of the dispersal of radioactivity, the IAEA's Illicit Trafficking Database contains some 470 confirmed cases of illicit nuclear trafficking. We have reasons to believe that the reports to the IAEA cover only a part of all trafficking cases. It is noteworthy that a majority of the cases appear to involve a criminal element. The purpose, however, is unknown — financial, environmental or malevolent use. All in all, the possibility that terrorists would use radioactive materials for malevolent purposes cannot be ignored.

This conference will focus specifically on the security of radioactive sources. Thus the conference programme does not include nuclear material, spent fuel, waste, nuclear installations or transports, which will have to be considered in a comprehensive approach to nuclear security. Otherwise, there may be security gaps that could be exploited by terrorists or other subnational groups.

2. IAEA PLAN OF ACTION TO PROTECT AGAINST NUCLEAR TERRORISM

In March 2002, the IAEA Board of Governors approved specific proposals to protect against terrorism involving nuclear or other radioactive materials. The plan of action contained eight Activity Areas, recognizing that a comprehensive approach to nuclear security is warranted. A global theme of the plan is to cover prevention, detection and response either for nuclear material, or for other radioactive materials or sources. Sustainable security systems rely on prevention and proper protection of the material in question. However, should prevention fail, measures must be in place to detect any theft, locally or at borders, and to respond to thefts or seizures of such materials, or to threats of such acts. The programme is advancing with a multitrack approach, namely the building of a framework of standards, guides and codes, making available to States a modular system of assessment or evaluation services, technical expertise, security upgrades, methodology development and training. More than 25 States contribute to the implementation of the programme with in-kind or financial contributions.

3. THE RDD — A WEAPON OF MASS DESTRUCTION OR DISRUPTION?

Let me now touch on some specific questions relative to using a radioactive source in an RDD. Millions of sources, in a large variety, are used daily, in all countries, in useful non-nuclear applications. But only a minor fraction of these sources contain radioactive isotopes in quantities and forms that would pose a terrorist threat. This conference will consider the factors that contribute to making a radioactive source attractive to terrorists, including its activity, availability and dispersal properties, and how to build an effective protection system for the sources. In doing so, the conference will also encounter studies which report that even the very strong sources may not be very ‘useful’ as weapons of mass destruction, since the number of immediate deaths from radiation would be very low, if any. The conventional explosion needed to set off an RDD would most probably inflict a much greater number of casualties. However, the resulting disruption would in all likelihood be major, possibly also fuelled by media reports. The fear of radioactivity could create panic, with associated disarray in the society. The dispersed radioactivity would require decontamination, costly and time consuming, and even limited radiation doses could cause long term health effects, and most certainly long lasting anxiety or psychological disturbances. It should be noted that these secondary, longer term, effects of an RDD explosion — the disruption — could be substantial and very difficult to restitute.

The willingness of terrorists to sacrifice their own lives to achieve their aims creates a new dimension in the fight against terrorism. However, since the radiation level of an unshielded strong source is very high, it should be considered that radiation sickness might occur early enough to make the adaptation of the source into an explosive device difficult. If the adaptation required heavy shielding, terrorists might find the source less attractive, owing to the resulting decrease in dispersal. Some high risk sources, however, may not require such shielding, thus making them more attractive. Other factors to consider are source mobility, and the physical and chemical form of the isotope. This conference provides an opportunity to review these and other factors that contribute to the assessment of threats and risks, and the potential consequences of a terrorist event. As is the case for the security of nuclear material, a threat assessment could and should be the basis for a graded approach to the physical protection of sources and for helping to target the strongest security to where it is most needed.

While nuclear security clearly remains a national responsibility, it is not a matter of exclusively national concern. An attack on a nuclear facility, the use of stolen nuclear material in a crude or improvised nuclear explosive device, or the use of radioactive material in a dispersion device, would have global consequences. Any such event would undermine confidence in nuclear technology.

4. INTERNATIONAL INSTRUMENTS

Let me touch on the international instruments that are recognized to contribute to the prevention of nuclear terrorism. The list of twelve international instruments related to the prevention and suppression of international terrorism includes the Convention on the Physical Protection of Nuclear Material. Ongoing efforts aim at strengthening this convention, inter alia, to broaden its scope to include the protection of nuclear material in domestic use, storage and transport. Also on the list is the International Convention on the Suppression of Terrorist Bombings, which establishes as an offence the delivery, etc., of a weapon or device through which there is a release, dissemination or impact of radiation or radioactive material. Furthermore, the draft Convention on the Suppression of Acts of Nuclear Terrorism contains obligations to make punishable offences all malevolent acts involving nuclear and other radioactive materials. The Non-Proliferation Treaty is also recognized for its contributions to nuclear security.

At a lower level, not legally binding but approved by the IAEA Board of Governors and the IAEA General Conference, are the Physical Protection Objectives and Fundamental Principles, referred to as Security Fundamentals, and the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, as well as the more recent Code of Conduct on the Safety and Security of Radioactive Sources, which is now being revised. These instruments provide an important basis for an internationally accepted platform for continued work on nuclear security.

5. RECENT PROGRESS AND LOOKING FORWARD

Now, where do we stand with our efforts to improve nuclear security? To date, the IAEA has carried out a large number of assessment missions and has provided technical advice and training for nuclear authorities, operators and law enforcement staff, contributing to improved nuclear security in Member States. Among the many ongoing initiatives, I wish to mention the regional and national training programmes to combat illicit trafficking, the efforts to improve and promote the development of detection instruments, and the measures to improve responses to seizures or thefts of radioactive material. Activities to locate and secure abandoned or lost sources, as well as to respond promptly to assistance requests when radioactive sources are seized in trafficking or are reported stolen, are important.

The IAEA, in pursuing its programme for protection against nuclear terrorism, provides a focal point for international efforts to improve nuclear security. The many ongoing activities depend on the active interaction with Member States and other international organizations. To further improve and strengthen our co-operation with Member States, we seek to establish Nuclear Security Support and Co-operation Programmes. By working together, co-ordinating our activities and pooling the available resources, we can make the world more secure, and nuclear applications, including the use of radioactive sources, will be for beneficial purposes only.

6. SUMMARY

We hope that this conference will help identify the additional measures that are needed, recognizing, inter alia, the need for a consistent and coherent approach to nuclear security. In doing so, the conference may reflect on the need to develop, promote and implement a security culture, a comprehensive and internationally accepted nuclear security framework, strengthened international co-operation and co-ordination, and education of the general public and the media concerning the benefits and risks associated with radioactive sources, and last but not least, while recognizing the need for and maintaining confidentiality of sensitive information, to improve communication to the general public, with the aim of generating confidence that nuclear security is an issue being addressed with the required attention.

It is also our hope that this conference will bring about or trigger the work needed to obtain a clearer picture of the threat of an RDD and of how to prevent that threat from materializing.

SECURITY OF RADIOACTIVE SOURCES: THREATS AND ANSWERS

A.J. GONZÁLEZ
Division of Radiation and Waste Safety,
International Atomic Energy Agency
Vienna
E-mail: a.j.gonzalez@iaea.org

Abstract

The general issue of the security of radioactive sources is presented as a prime but constitutive element of radiation safety, focusing particularly on the perceived threats for the malevolent use of radioactive sources and on the possible answers to these threats. The paper discusses the source security threat and the possible international response, and presents an overall outlook for the future.

1. INTRODUCTION

After the terrorist attacks on New York and Washington, increasing public apprehension has evolved worldwide about a topic imprecisely termed security of radiation sources. The issue in the public mind can be simply formulated as follows: could a concoction of radioactive substances added to conventional explosives be turned into a device for malevolent use and the induction of terror? The media promptly dubbed the new possible menace a 'dirty bomb' — a nickname that does not alleviate public uneasiness.

Certainly, exploding a radioactive source can disperse its radioactive content. Moreover, if the radioactive substance in the source is a dispersable material, the radioactive content could be released into the environment by merely opening the source container. (Perhaps for this reason, scientists prefer to call this potential terrorist ensemble a 'radiological dispersal device', or RDD, rather than dirty bomb.) These types of malevolent acts would certainly disseminate radioactive particles and spread radioactive contamination. If carried out in an urban environment, a number of city blocks could be significantly contaminated; if performed in a subterranean metropolitan train system, it could paralyse a city. Whereas diffusion of the contamination would moderate and constrain the health effects of such a device, the public may have a different perception. An RDD will not produce a large number of casualties, but terror and psychological trauma will certainly follow its explosion.

Are these scenarios of terror feasible? In fact, radioactive sources are extremely beneficial to humankind, being commonly and ever more widely used in a broad range of medical, industrial, agricultural and research applications. Not surprisingly, they are globally abundant and to restrict their use because of malevolent threats would mean to give in to terrorist aims and would be a disservice to the world — particularly to developing countries. Some of these sources contain large amounts of radioactive material and a number of them are unsecured and may easily fall into malevolent hands, becoming a real threat for society. They vary widely in physical size and properties, in their radioactive content, and in ease of access for diversion purposes. Worldwide, no stringent security measures are generally applied to chemical or biological products, and radioactive sources are no different. Source security has traditionally been confined to preventing accidental access or petty theft (such as stealing shielding materials). Certainly no sophisticated antiterrorist security measures are commonly in place for radioactive sources and even those that are well regulated could be stolen and diverted with relative ease, as is the case for most chemical or biological substances. This problem was widely recognized long before 11 September 2001 and the need for securing radioactive sources has always been high on the agenda of the international radiation safety community. It certainly was an integral part of the radiation safety programme of the IAEA, where source security, or the prevention of relinquishing control or of unauthorized possession of radioactive sources, has always been considered an essential precondition of radiation safety.

The concepts of radioactive source security and radiation safety have been mixed up and unprofessionally used. Confused communication, mainly caused by this loose use of terminology (and sometimes exacerbated by difficulties with translation) has contributed to increasing anxiety over this issue, which was largely triggered by the post-September-11th trauma. The terms safety and security have many meanings, depending on the context in which they are used, and one is not clearly distinguishable from the other — at least in common parlance. In fact, safety and security are two distinct terms in English (and also in French — sûreté and sécurité), but a common word is used for these two concepts in other major international languages such as Russian, German or Spanish. Not surprisingly, therefore, non-English (or French) speakers wonder what the distinction between safety and security (or sûreté and sécurité) actually is. Should English (or French) speakers reach for their dictionaries, they would perhaps be none the wiser: one of the definitions of safety is security and vice versa (and one of the definitions of sûreté is sécurité and vice versa).

Within the context of radioactive sources, however, the concepts of safety and security have been internationally used with a rather precise connotation.

The safety of a source denotes the assembly of administrative, technical and managerial features aimed at diminishing the likelihood of people incurring radiation harm as a result of radiation exposure from such a source. In contrast, the security of a source refers to features aimed at preventing any unauthorized possession of, and actions with, the source, by ensuring that control over it is not relinquished or improperly acquired. Source security is an essentially necessary, but not necessarily sufficient, element for source safety. It follows that within the framework of radioactive sources, source security is subsidiary to source safety. In fact, a radioactive source can be secure, namely be kept under proper control and physically protected, but this does not necessarily mean that the source is also safe, namely unlikely to harm people. (For instance, it could be that the source is well locked and physically protected but that its radiation beams are not properly shielded or its radioactive content not well sealed and contained.) Conversely, a radioactive source cannot be judged to be safe if, inter alia, it is not secure. This analysis leads to two logical conclusions: first, the safety and security of radioactive sources are intrinsically linked one with the other; second, source security must be an important but subordinate element of source safety, not the other way around. The subsidiary nature of the security of radioactive sources with respect to their safety has been recognized over the years in both international and national standards dealing with radiation, where security requirements have been placed as important but not all-encompassing elements of safety standards.

Thus radiation safety is concerned with preventing adverse health and environmental impacts from radiation sources in general, and radioactive sources in particular. Radioactive source security is about preventing loss of control of the source, either inadvertent or intentional and even malevolent, and thereby inducing a breach of radiation safety. Inadvertent loss of source control can arise because the source is misplaced, forgotten, accidentally lost or insecurely stored, and until recently these mishaps were the main focus of radioactive source security. Serious consideration of intentional breaches in source security for malevolent purposes, including intention to harm others and terrorist threats, is a relatively new, post-September-11th issue, and it is not a simple issue. As indicated before, the world has plenty of radioactive sources, their security is not homogeneously stringent and a number of sources are ‘orphans’ outside of any control. Radioactive sources are therefore more likely to land in the wrong hands than, for instance, the nuclear materials used in the production of nuclear weapons or even in the civilian nuclear installations used for nuclear power production, as these are both scarcer and better secured than radioactive sources. On the other hand, why radioactive sources should be the focus of security interest when hundreds of dangerous chemicals and biological agents are readily available for harmful terrorist acts is not evident. While an RDD could be an element of terror, its potential effects cannot be compared with the catastrophic consequences of a nuclear, chemical or biological weapon — but the public does not necessarily perceive the difference.

Unfortunately, the post-September-11th syndrome creates much confusion in the objective understanding of the security threats posed by radioactive sources. First, the basic concepts of source safety and source security are mixed up (with officials sometimes publicly and surprisingly declaring that security requirements should override safety considerations). Second, the potential detrimental impact of an RDD is sometimes exaggerated, even by members of the 'intelligentsia'. Perhaps those involved in these pronouncements do not comprehend their possible long term consequences for public trust.

Within the framework described in this introduction, the subject of my presentation is the general issue of security of radioactive sources as a prime but constitutive element of radiation safety. I will particularly focus on the perceived threats for the malevolent uses of radioactive sources and on the possible answers to these threats. In brief, the content of my presentation includes: the source security threat already mentioned in the opening speeches, the possible international response and an overall outlook for the future.

2. SECURITY THREATS POSED BY RADIOACTIVE SOURCES

It has been suggested that the major issues of concern can be summarized as follows:

(i) Radioactive sources are abundant and therefore easily available throughout the world.
(ii) Many radioactive sources have been orphaned of any control, and some of these, holding large radioactive inventories, were originally intended for unconventional uses.
(iii) Even those radioactive sources that are well regulated are not necessarily well secured and orphan sources are usually completely unsecured.
(iv) Badly secured radioactive sources are amenable to diversion into malevolent use and potential terror.

I agree that these issues summarize the security threats posed by radioactive sources and I will address them individually.

2.1. Worldwide abundance of radioactive sources

Radioactive sources are extensively and commonly used in medicine for both diagnostic and therapeutic purposes. Radiodiagnostic techniques commonly employ non-radioactive radiation sources — usually X ray machines — which, therefore, do not present an evident serious security threat. When radioactive materials are used for diagnostic purposes — notably in nuclear medicine procedures — the amount of radioactivity used is small and again does not present a security hazard. Radiodiagnostic apparatus, therefore, can be generally excluded from security considerations. Conversely, in radiotherapy, radioactive sources containing large amounts of radioactive materials are commonly used. There are two main radiotherapeutic techniques: teletherapy, or the irradiation of tumours with a radiation beam external to the body, and brachytherapy, or the intracavitary use of radiation sources. Many medical sources are composed mainly of the radioactive element cobalt-60, which — because it is a metal — is not amenable to dispersion; moreover, its half-life of around 5 years limits potential long term concerns. Less frequently, the radioactive element caesium-137, with a half-life of around 30 years, is employed. Many caesium sources were manufactured using the compound caesium chloride (CsCl), a salt whose physical form is a highly dispersable powder similar to talc in its spreading properties.

More than 10 000 teletherapy sources containing capsules of cobalt-60 are in use worldwide. Each source has a radioactivity of some hundreds of trillions of becquerels, or 10^{14} Bq, which is equivalent to a few thousand curies. While cobalt, being a solid metal, is not easy to disperse, the teletherapy cobalt capsules usually contain around 1000 pellets, each pellet having a radioactive content of around 10^{11} Bq, or several curies. Therefore, the thousand constitutive pellets of a teletherapy cobalt capsule are easily ‘dispersable’ if a malevolent intent exists. The available information on teletherapy sources containing caesium-137 is scarcer. These sources were used when this type of therapy first started but their use was abandoned in favour of cobalt-60. Some teletherapy caesium sources are still in service, mainly in developing countries that could not afford the changeover to cobalt-60 units. The amount of radioactivity of each teletherapy caesium source is similar to the cobalt-60 sources, i.e. around 10^{14} Bq. The difference, however, is the high dispersability of the CsCl compound, which makes the sources particularly tailored to any malevolent intent to contaminate a public environment. Brachytherapy is commonly performed manually (and sometimes using the method known as remote after-loading) with sources of radium-226, caesium-137 and iridium-192, with a radioactivity content of around 10^8–10^9 Bq per source. These sources are more abundant, and easier to acquire for malevolent purposes, than teletherapy sources but their individual radioactivity is orders of magnitude lower and, unless they are accumulated, they appear to be less amenable to malevolent use for spreading significant contamination.

Radioactive sources are even more abundant in industry, where they are used in applications such as irradiation of products, radiography of metallic parts, and gauges. Around the world there are about 300 industrial irradiators, huge installations containing extremely large amounts of radioactivity. (Their radioactivity content is so high that it is difficult to express it in the activity unit becquerel, as it amounts to billions of billions of becquerels; in fact, their radioactivity content ranges from 10 000 to 1 million curies per facility.) They are usually employed for sterilizing medical products, such as syringes, and for preserving food. In addition, a few thousand smaller self-contained units, each with radioactivity of a few thousand curies or hundreds of trillions of becquerels, are in operation around the world. The radioactive element used in industrial irradiators is mainly metallic cobalt-60, with numerous 'rods' containing thousands of pellets of cobalt-60 composing the source, but some facilities are still equipped with sources of caesium-137. The radioactive sources of industrial irradiators could pose a serious security hazard; but they are not easy to divert to malevolent purposes, as perpetrators would most likely die almost instantaneously from overexposure.

Numerous radioactive sources are used worldwide for purposes of industrial radiography, particularly in countries with large oil and gas piping installations. The number of sources used in this practice is estimated to be several tens of thousands. Around 80% of the sources contain the radioactive element iridium-192; the remainder are sources of cobalt-60, selenium-75 and ytterbium-169. The typical activity is around 50–100 Ci each or around three trillion becquerels. Their physical form is usually encapsulated metal, which makes them resistant to dismantlement. While these sources are therefore unlikely to pose a serious contamination hazard, they can produce significant injuries to individuals in contact with the source. It is relatively easy to steal an industrial radiography source and divert it to malevolent purposes, but difficult to accumulate a larger number as they are usually stored at different industrial locations. Currently, around 10 000 iridium-192 industrial radiography sources are supplied annually and replaced approximately every half a year. Their activity is around 1–300 Ci, but typically 50 or 100 Ci. Their physical form is a metal pellet. The supply of cobalt-60 sources is approximately 200 per year with 1000–2000 in circulation. Their activity is 10–500 Ci, but mostly 100 Ci. In addition, around 1000 radiography sources holding selenium-75 and ytterbium-169 radionuclides are supplied annually; their activity range is 10–30 Ci.

Finally, millions of sources having a relatively low radioactive content are used as industrial gauges and in other applications. In the United States of

America alone a few million sources are registered under the system of 'general license', a lighter mechanism of regulatory control. They usually contain cobalt-60, caesium-137 or americium-241, and their typical activity is a few curies each. They come in many physical forms and their regulatory control is particularly lenient in many countries. They pose a very minor security risk, but could lead to small scale but easily measurable contamination.

2.2. Orphaned radioactive sources

Competent governmental regulatory authorities around the world exercise control over the vast majority of radioactive sources for civilian use. They usually subject the sources to a system of registration, licensing,

FIG. 1. Abandoned radioactive sources.

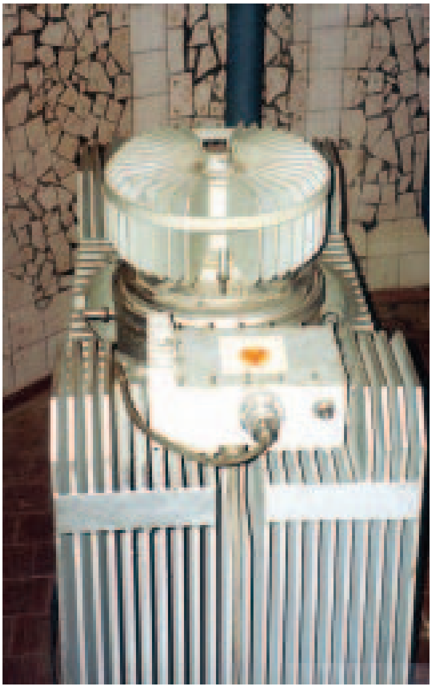

FIG. 2(a). A strontium-90 thermogenerator from the former Soviet Union.

authorization and regular inspection. As the sources reach the end of their expected working lives and are no longer needed, they should be disposed of safely and securely under conditions specified by regulations. However, often — all around the world — unneeded radioactive sources are simply discarded by relinquishment of their control and thus they became abandoned and orphaned of any control (Fig. 1). These orphan sources may have never been subjected to regulatory control or were initially regulated but eventually abandoned, lost or misplaced, stolen or removed without authorization. It is suspected that a large number of industrial and medical radioactive sources are orphaned worldwide each year, but the precise quantity and their location are largely unknown.

2.3. Unconventional and powerful orphan sources

Reports of accidents involving unconventional orphan sources in the new States resulting from the dissolution of the Soviet Union have caused particular security concern. Following the dissolution of the Soviet Union, the new

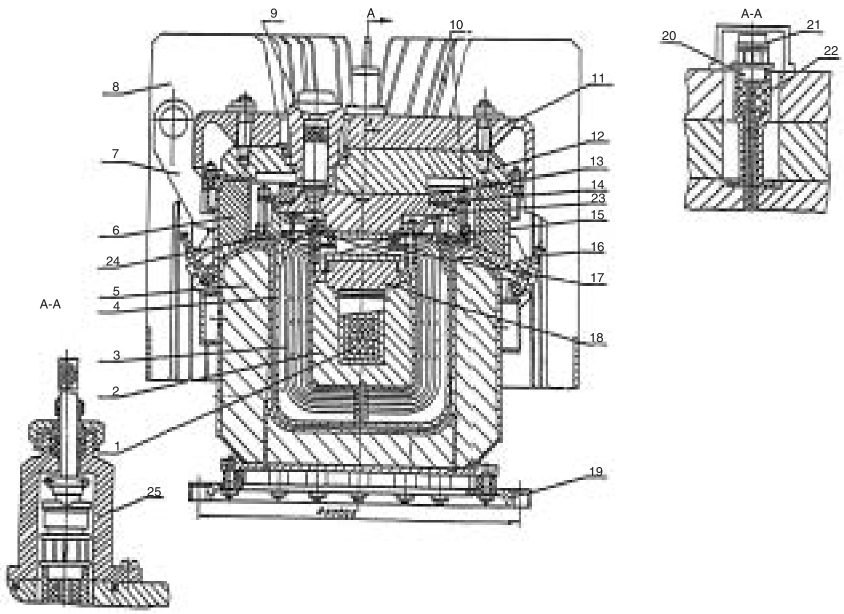

FIG. 2(b). Construction of a radioisotope thermoelectric generator. 1: Radioisotope source; 2: shielding unit; 3: screening block; 4: casing; 5, 6: radiation shield; 7: lug; 8: cooling unit; 9: valve; 10: bolt; 11: radiator; 12: copper cover of cooling unit: 13: flange; 14: cover; 15: support of heat source: 16: bolt; 17: thermoelectric unit; 18: thermojunction; 19: base; 20: plug connection; 21: short circuit socket; 22: sleeve; 23: gasket; 24: ring with springs; 25: cable.

emerging States — some of which were not even aware of the existence of such sources — have not exercised any control over them. Notable cases of particular concern are abandoned thermogenerators of electricity containing powerful radioactive sources of strontium-90 (Fig. 2), which were introduced in the 1970s for dual civilian/military use.

Radioisotope thermogenerators were used in various civilian and military applications, for example to power navigational beacons and communications equipment in remote areas. They usually hold an enormous radioactive content: over 40 000 Ci of strontium-90 (for comparison, this is the order of magnitude of strontium-90 activity that was released from the Chernobyl accident). These types of generators have also been built in the USA and their radioactive content is more or less of the same order of magnitude (Fig. 3).

A large number of navigational beacons powered by these thermogenerators were operated in the Arctic area from Novaya Zemlya to the Barent Straits (it seems that more than 600 of these may be located in the Arctic region, and more than 100 in the Murmansk area). In Alaska, several US-built

FIG. 3. Thermogenerators from the USA.

generators were located in the Burmont area. Many thermogenerators are now being recovered and their sources are being recycled.

The first abandoned thermogenerator was found in the Ingury River in the Republic of Georgia. When the water level of the river went down, its powerful radioactive source, partially shielded, suddenly appeared in what was the riverbed. The thermogenerator, which was recovered by the Georgian authorities with the help of the IAEA, was of Soviet origin.

The IAEA also found thermogenerators in Tajikistan, dumped in an abandoned building, completely unsecured and easily removable by the public (Fig. 4). Sometimes part of the shielding has been discovered but without the radioactive source.

FIG. 4. Dismantled and abandoned thermogenerators in Tajikistan.

A number of thermogenerators have also appeared in Belarus but these are fortunately now secure (Fig. 5). They have been placed in other territories of the former Soviet Union and even in other parts of the world, apparently also in the Antarctic.

Another worrying case of an unconventional radioactive source is a large apparatus manufactured in the former Soviet Union known as a *gamma-ear-of-corn*, or гамма-колос in Russian (pronounced *gamma koloss*), which were used for agricultural purposes (Fig. 6).

The гамма-колос sources, holding a large activity of 3500 Ci of powdered caesium-137 chloride, were originally mounted on trucks. Many were produced in the former Soviet Union and distributed around its territory.

Following the dissolution of the Soviet Union, many гамма-колос were simply abandoned and some dismantled (perhaps so that the truck could be used for other purposes). Some of the sources were stored in precarious conditions, such as those in Moldova presented in Fig. 7.

FIG. 5. Secured thermogenerators in Belarus.

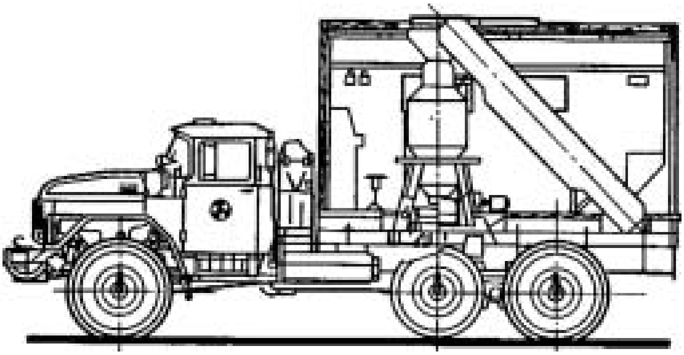

FIG. 6. A гамма-колос source mounted in a truck.

FIG. 7. Dismantled and stored гамма-колос sources in Moldova.

2.4. Light security

Even well regulated radioactive sources are not necessarily well secured. Often, no stringent security measures are applied to radioactive sources. Traditionally the security aim has been confined to preventing accidental access to the sources or petty theft (such as stolen shielding materials) and, usually, no sophisticated antiterrorist security measures are available for radioactive sources. Radioactive sources could be stolen and diverted with relative ease. Potentially the control of regulated sources can be simply relinquished by the user and, as a result, they could be easily taken away. Obviously, orphan sources are even easier to divert. Both non-controlled regulated sources and orphan sources are prone to fall into malevolent hands. Embezzled sources can be transferred without difficulty. They are small in size; even shielded they can be easily concealed in a truck and unshielded they can fit into a suitcase. In any case they can be easily removed, particularly if the perpetrator is willing to disregard his or her personal safety. By shrouding a radioactive source with explosives, and detonating it in an appropriate manner, radioactive contamination could be spread in the environment, and public terror easily created.

It is to be noted, however, that robbers of radioactive sources have not traditionally had malevolent criminal intent; rather, they have mainly been people who have committed petty theft, removing sources for financial gain or simply out of curiosity or ignorance. In fact there is no record of a radioactive source having been stolen for sabotage or terrorist activities — except for a number of cases related to the Republic of Chechnya in the Russian Federation. (According to Russian press reports, around a decade ago, Chechens used a canister containing the radioactive element caesium to scare shoppers in a Moscow marketplace and, in 1998, officials in the Republic defused a booby trapped explosive attached to a container of radioactive material.)

2.5. Benchmarking potential malevolent acts

In sum, a radioactive source can be easily converted into an RDD and the potential aftermath and scenario of terror are not theoretical. Serious consequences from non-criminal security breaches with radioactive sources have already occurred. These cases, many of which have been reported by the IAEA, could be used as a benchmark for estimating the consequences of a terrorist use. For instance, a decade and a half ago, in the large city of Goiânia in Brazil, a security breach occurred leading to a radiological accident that can be considered as a yardstick of what could happen in a terrorist act involving a radioactive source. A caesium-137 teletherapy unit was discarded without notification being given to the licensing authority. The former premises were subsequently partly demolished and the caesium-137 source became unsecure. Two scavengers entered the premises and, not knowing what the unit was but thinking it might have scrap value, removed the source assembly from the 'head' of the machine. This they took home and tried to dismantle. In the attempt, the source capsule was ruptured. Contamination of the environment ensued. As a result of this event, 14 people were overexposed and 4 died within four weeks. Around 112 000 people had to be monitored and 249 were found to be contaminated. Hundreds of people had to be evacuated. Hundreds of houses had to be monitored; 85 were found to be contaminated, and some had to be demolished (Fig. 8.) The full operation of decontamination produced 5000 m^3 of radioactive waste (Fig. 9).

The social impact was such that the city of Abadia de Goiás, a suburb of Goiânia, where the waste repository was installed, has incorporated the trefoil symbol of radioactivity into the village flag.

This was not the only case of security breaches intensively studied and reported by the IAEA. For instance, in the Estonian village of Tammiku, in 1995, five people in one home were killed after someone found a tiny

FIG. 8. Demolishing houses in Goiânia.

FIG. 9. Radioactive waste from the Goiânia accident.

radioactive metal fragment in a nearby field and put it in a kitchen drawer. The fragment, whose origins are unknown, poisoned the family over several weeks. In another example, in Samut Prakarn, Thailand, a group of scrap dealers cut through the shiny metal contents of a stolen cancer treatment machine and removed the cobalt-60 radioactive source. Three of the dealers died and 11 others suffered severe radiation effects. Investigators found two more stolen cancer treatment machines awaiting the scrap dealers in a suburban Bangkok parking lot. Authorities and the media have reported on other similar events. An Egyptian farmer and his young son died of radiation poisoning after taking home a cylindrical source left behind in their village by a construction crew. Five other family members were hospitalized with skin eruptions, and some of their neighbours fell ill. The tiny metal cylinder, containing radioactive iridium, came from a radiography source commonly used to screen weld pipes. In Algeciras, Spain, and in the Transnistria region of Moldova, just to mention two cases, orphan radioactive sources of unknown origin mixed with metal scrap entered a foundry and were melted, contaminating the premises, releasing radioactive materials into the environment, and creating situations of public anxiety and huge economic damage.

3. ANSWERING SECURITY THREATS POSED BY RADIOACTIVE SOURCES

3.1. A pre-September-11th issue

Strengthening the security of radioactive sources is not a new challenge for the IAEA — the UN nuclear watchdog, as the media have labelled it. The IAEA has an international mandate in the protection of health against exposure to ionizing radiation, and any type of breaches in the security of radioactive sources may cause such exposure. It is authorized by its Statute to establish pertinent international standards and to provide for their application at the request of a State and, jointly with other specialized agencies, it has set up international standards that include requirements on the security of radioactive sources. Thus, since the early 1990s, the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, or BSS, have established radioactive source security requirements that are subsidiary to the wide radiation safety requirements applied to any source. The BSS require, inter alia, that radioactive sources shall

> "be kept secure so as to prevent theft or damage…by ensuring that:…control of a source not be relinquished…a source not be

transferred unless the receiver possesses a valid authorization…and…a periodic inventory of movable sources be conducted at appropriate intervals to confirm that they are in their assigned locations and are secure."

Similar subsidiary requirements exist at a national level; for instance, the US Code of Federal Regulations requires that licensees holding radioactive sources shall secure them from unauthorized removal or access.

The IAEA has also a mandate in the implementation of relevant obligations undertaken by States through international conventions, notably the conventions on notification of radiological emergencies and on emergency assistance, that are applicable to the aftermath of attacks involving RDDs.

3.2. Dijon conference: International Action Plan and Code of Conduct

While the IAEA security standards can be traced back to 1992, not until 1998 did governments become fully concerned with the international dimensions of the security threats associated with radioactive sources. In that year, the IAEA, jointly with the European Commission, the International Criminal Police Organization (ICPO-Interpol) and the World Customs Organization (WCO), organized the first international conference on the issue, in Dijon, France. In the Dijon conference, hundreds of specialists and governmental representatives from Member States of those organizations discussed the problem for the first time and produced concrete recommendations. Subsequently, the IAEA General Conference decided to implement an international Action Plan that included measures to strengthen the global security of radioactive sources[1]. Among other relevant actions already completed, the sources deemed to be a security threat were generically identified and classified, and a non-binding 'Code of Conduct' for States was adopted[2].

3.3. Buenos Aires conference: Concern of national controllers

Closer to the September 11th events, in December 2000, another topical international conference, this time assembling national authorities regulating

[1] See Attachment 2 of IAEA document GOV/1999/46-GC(43)/10.

[2] On 11 September 2000, the IAEA Board of Governors took note of the Code of Conduct on the Safety and Security of Radioactive Sources and, on 22 September 2000 in resolution GC(44)/RES/11, the General Conference, after welcoming the progress made in implementing the Action Plan, including the successful preparation of the Code of Conduct, endorsed the actions taken by the Board. The Code of Conduct was subsequently issued by the IAEA as publication IAEA/CODEOC/2001.

the security of radioactive sources, was convened by the IAEA in Buenos Aires, Argentina[3]. The Buenos Aires conference recommended updating and strengthening the Action Plan. At its March 2001 session, the IAEA Board of Governors was informed about the major findings of the Buenos Aires conference, and after welcoming the fact that the conference had achieved its purpose of facilitating a broad exchange of information among national authorities, the Board noted its major findings and requested the Secretariat to assess their implications for the Action Plan, to implement any adjustments to the Action Plan that might become necessary in the light of those major findings and of comments by Member States, and to inform the Board and the General Conference of any such adjustments. The Board approved a revised Action Plan on 10 September 2001 — just one day before the terrorist attacks on New York and Washington[4].

4. OUTLOOK

4.1. A renewed strategy: Maintaining the concepts, widening the scope

It is clear that the events of 11 September created new dimensions in the old issue of securing radioactive sources:

- The potential aim to cause widespread panic and harm among civilian populations;
- The perceived ability of malevolent groups to work with modern technologies;
- The possible suicidal approach of the perpetrators (the deadliness of handling intensely radiological material can no longer be seen as an effective deterrent);
- The global characteristics of the threat.

The IAEA strategy had to accommodate these new dimensions accordingly.

[3] The International Conference of National Regulatory Authorities with Competence in the Safety of Radiation Sources and the Security of Radioactive Materials was organized by the IAEA in co-operation with Argentina's Nuclear Regulatory Authority, and hosted by the Government of Argentina in Buenos Aires, in December 2000. The conference was attended by 89 representatives of the regulatory bodies of IAEA Member States.

[4] See Attachment to IAEA Document GOV/2001/29-GC(45)/12.

Under the motto "a global threat requires global action", the IAEA, with the strong financial support of donor States, renewed its strategy and dramatically expanded its activities related to radiation source security. The Nuclear Security Plan of Activities[5] includes a specific activity on radioactive source security. A renewed Action Plan, which takes account of all these experiences and of the outcome of this conference, will be presented at the forthcoming meetings of the IAEA's policy making organs in September 2003.

The dictum under the new strategy is security of radioactive sources from cradle to grave. This means considering security at the stages of: manufacture, distribution, installation, commission, use and disposal of radioactive sources, rather than only at the stage of usage, as was implicit in the pre-September-11th practice.

In sum, the IAEA's overall renewed strategy in the security of radioactive sources can be briefly formulated as follows: assisting Member States to create and strengthen national regulatory infrastructures in order to ensure that significant radioactive sources are localized, registered, secured and controlled from cradle to grave. The application of this strategy is adapted to the new security dimension: before it was targeted at breaches in security caused by innocent mistakes or petty theft; today the scope has been widened to include malevolence and terrorism.

4.2. Role of the IAEA

The role of the IAEA is not changed by the renewed strategy but simply reinforced. As indicated before, the IAEA's role is straightforward: establishing international standards and providing for their application at the request of States. In order to provide for the application of these international standards, the IAEA uses a variety of mechanisms — including the provision of technical co-operation and education and training, and the fostering of information exchange, as well as the performance of peer review appraisals of the security situation in a requesting State. Assisting the developing world and rendering appraisal services to ensure compliance with security requirements are important mechanisms.

4.3. Assisting the developing world

Even the smaller and less developed countries make use of radioactive sources. It is to be expected that where resources are scarce, the stringent control of radioactive sources is not a high priority. The IAEA has been responsive to this reality and, some years ago, launched a technical

[5] See IAEA Document GOV/2002/10.

co-operation project (the Model Project) aimed at strengthening national regulatory infrastructures in developing Member States, and thus enhancing their radioactive source security. This is an example of an effective way of strengthening national control systems. The Model Project initially enrolled the 52 IAEA Member States presenting the more urgent needs for source control infrastructures; it now has expanded to more than 80 countries.

It is to be noted, however, that IAEA assistance can be rendered only to those developing countries that are Member States of the IAEA. Around 50 countries of the UN membership are not IAEA members. In addition, there are a number of political entities that are not even UN members. In all of these territories, radioactive sources are being used but IAEA assistance cannot reach them. It is suspected that in many of them the control of radioactive sources simply does not exist; perhaps the local authorities are not even aware that they have a problem to deal with.

The desire of the developing world to tackle this problem is clear. For instance, in April 2001, during the First Africa Workshop on the Establishment of a Legal Framework Governing Radiation Protection, the Safety of Radiation Sources and the Safe Management of Radioactive Waste, which was organized by the IAEA, held in Addis Ababa, Ethiopia, and attended by 35 participants from 14 Member States, the issue was debated. The workshop adopted a Common Position on the Establishment of a Legal Framework Governing Radiation Protection, the Safety of Radiation Sources and the Safe Management of Radioactive Waste (the Common Position). In the Common Position, the participants

> "…recogniz[ed] that most African countries lack the capacity for the environmentally sound disposal of sources that have outlived their useful life" and "not[ed]…that manufacturers of radioactive sources should be required to return sources to the country of manufacture and that exporting States should be responsible for ensuring that manufacturers duly carry out their duties of reshipment and disposal of sources that have outlived their useful life".

The participants also

> "…not[ed] the need for the adoption and implementation of an internationally legally binding instrument setting out appropriate rules and procedures regarding the return of sources that have outlived their useful life in importing African countries".

In addition, the participants called upon the IAEA to

"…create a forum for African countries to consider the Code of Conduct on the Safety and Security of Radioactive Materials and give it a legally binding effect so that the safe and peaceful use of nuclear technology is not compromised."

4.4. New initiatives

In the opening addresses to this conference it was stated that the world faces new international initiatives on recovering and recycling orphan sources and strengthening national systems of control. Recently, the Ministry of the Russian Federation for Atomic Energy, the US Department of Energy and the IAEA reached an agreement for a new initiative termed Securing and Managing Radioactive Sources. This tripartite project, which is being organized and managed by the IAEA, aims at securing radioactive sources in the newly independent States of the former Soviet Union. Its objectives are: developing an inventory of relevant sources, and their actual or likely location; locating the sources; recovering them; storing them in a secure manner; and recycling them. This tripartite initiative is a good example of international co-operation for the recovery and recycling of orphan sources.

It is evident that a number of actions are urgently needed: registers for tracking sources should be set up; programmes for recovering orphan sources should be launched; regulations limiting the export of high risk sources to States that have effective controls should be established; notification requirements to recipient States of exports should be implemented; measures to penalize theft or misuse of radioactive sources should be instituted; physical protection measures and access controls for high risk sources should be set up; and legislation to ensure the safe and secure disposal of high risk spent sealed sources should be passed.

In planning these new initiatives, it is perhaps convenient from a logical point of view to divide the issues between those already existing, for which retrospective remedial measures are required, and those that are related to the future, for which prospective actions are needed.

— *Retrospectively*, existing high risk radioactive sources that are not under secure and regulated control, including orphan sources, raise serious security and safety concerns. Action is required to locate, recover and secure powerful radioactive sources still at large and to control other sources. Therefore, an international initiative aimed at facilitating the location, recovery and securing of such radioactive sources throughout the world needs to be launched, perhaps under the aegis of the IAEA, with particular emphasis on sources with the potential for posing a significant radiological risk. The recent tripartite initiative of the Governments of the Russian Federation and the United States of America and the IAEA launched with similar objectives in countries of the former Soviet Union could serve as a model.

— *Prospectively*, effective national infrastructures for the safe and secure management of vulnerable and dangerous radioactive sources are essential for ensuring the long term security and control of such sources. In order to promote the establishment and maintenance of such infrastructures, States should make a concerted effort to observe closely the principles contained in the Code of Conduct and the requirements of the BSS. Therefore, an international initiative to encourage and assist governments in their efforts to establish such infrastructures needs to be launched, perhaps under the aegis of the IAEA. The IAEA Model Project could serve as a model.

The retrospective initiatives may include actions aimed at:

— Considering how best to globalize the efforts relating to the security of existing high risk radioactive sources and, with this objective, brokering partnerships among States;
— Identifying, locating and assessing the security of radioactive sources, with emphasis on high risk vulnerable sources (aerial searches are one possibility; in Georgia this was done by the IAEA with the help of France);
— Applying existing international guidance, such as that given in IAEA-TECDOC-1355, and national design basis threat methodologies, to determine upgraded security needs;
— Appraising existing security measures for radioactive sources, based, for example, on IAEA-TECDOC-1355;
— Transporting, consolidating, conditioning, storing, returning or disposing of existing sources in a secure manner;
— Establishing a confidential repository of information related to existing radioactive sources;
— Combating illicit trafficking of radioactive sources by establishing effective measures to detect, interdict and respond to incidents of theft, illicit possession and illicit trafficking, and providing assessment and advisory services on border monitoring, training and technical support, including state of the art detection equipment.

The prospective phase may for instance include the following initiatives:

— Developing a co-ordinated overall international strategy for the provision of assistance to States where high risk vulnerable sources are used, stored or transported based on each State's particular needs. This may include undertaking national strategy missions, upon request, in order to: appraise the State's legislative and regulatory control of sources; assist in developing or improving legislative and regulatory infrastructure, and implementing a national plan of action for improved management of radioactive sources throughout their life cycle.

— Revising the IAEA Regulatory Authority Information System (RAIS) in order to meet the management and record keeping needs of a regulatory authority and (particularly) to facilitate States' implementation of the Code of Conduct and the BSS requirements, and the provision of RAIS and necessary supporting software and hardware to States in order to assist in the regulatory control of radioactive sources, particularly those posing a high risk.

— Assisting States in the implementation of the Code of Conduct and the BSS, including: encouraging States to adhere to the Code of Conduct; assessing the degree of implementation of the Code of Conduct and the BSS by States, with a focus on the elements that are of greatest relevance in preventing malevolent use; dialoguing with manufacturers and suppliers of radioactive sources, regulatory bodies and users on the appropriate means of controlling the export, use and return of radioactive sources consistent with the implementation of the Code of Conduct; and assisting manufacturers and suppliers of radioactive sources in the development of an appropriate Code of Practice that defines their roles and responsibilities during the life cycle of high risk sources.

— Developing and establishing recommendations, guidance, norms and standards, including: an international security oriented categorization of radioactive sources (see IAEA-TECDOC-1344)[6], which is particularly important in that it provides a basis for the definition of the scope of the Code of Conduct; technical documents to give interim guidance on the security of radioactive sources (see, for example, IAEA-TECDOC-1355); standardized formats for national registers of radioactive sources, facilitating the efficient exchange of information between States; internationally agreed procedures for importing and exporting radioactive sources; a standardized format for the authorization of radioactive sources to facilitate the exchange of information between Member States, particularly with respect to import/export controls, complementing both the IAEA Regulations for the Safe Transport of Radioactive Material (TS-R-1) and the security requirements for transports of nuclear material that are currently provided in IAEA INFCIRC/225/Rev. 4; methodologies for

[6] As reported in GOV/2003/38.

assessing threats to, and vulnerabilities of radioactive materials consignments as potential targets for terrorist acts; procedures to permit appraisals of security measures for radioactive sources; guidance to enable States to perform their own assessments of their degree of control over radioactive sources; implementation of the BSS security requirements for specific practices involving the use of radioactive sources, including gauges, well logging and research; and supporting the work of other organizations such as the International Organization for Standardization in the development of standards for source design, construction and testing to take into account concerns related to malevolent use of high risk sources.
— Promoting research and development, in co-operation with national laboratories and radioactive source manufacturers, in areas such as: feasibility of source design and institutional measures that will minimize the consequences of malevolent use; and disposal options for sealed sources, including establishing and gaining international consensus on standards for borehole disposal, assessment methods and approaches to demonstrate compliance with standards, demonstration of the feasibility of the technology, and assistance to Member States on development and licensing of facilities.
— Providing direct technical services, advice and assistance to States, in order to deal with the legacy, and further generation, of high activity disused radioactive sources, in areas such as: the development, certification and use of shipping containers for the safe return of disused or conditioned radioactive sources; the design and construction of operational areas for handling and conditioning spent high activity radioactive sources; the design and construction of long term storage containers for radioactive sources; and the conditioning of long lived radioactive sources.

All these new initiatives, however, will only be fully effective if the Code of Conduct becomes a binding undertaking among States. First, the Code should be reviewed in order to adapt it to the new security dimensions of the problem. Then, all countries should be encouraged to strengthen controls on radioactive sources by observing the revised Code of Conduct.

5. CONCLUSION

Our dilemma with security issues related to radioactive sources is one of equilibrium. On the one hand, we should not overreact: people need radioactive sources; if we overreact we fall into the terrorists' trap. On the other hand, we have to show responsibility in the face of the transformed threats posed by radioactive sources.

In his address to the IAEA's 2002 General Conference, the US Secretary of Energy stated: "…the role of the IAEA is absolutely critical to ensuring the success…for our work on Radiological Dispersal Devices." He went on to add:

> "…I call on all states to join the United States in working with the IAEA to address the threat posed by the potential misuse of radiological materials. I am proposing an international conference to discuss how the international community can build on the tripartite initiative launched by the United States, Russia, and the IAEA to extend our efforts globally."

The IAEA promptly followed up this advice and organized this conference. The objective is to foster a wide exchange of information intended to identify the key issues connected with the threat posed by the potential misuse of radioactive materials with malevolent purposes and ways to address them. I expect that it will serve to share knowledge and experience about the problem and search for possible solutions to reach a common understanding on the nature of the threat, on ways to diminish the likelihood of occurrence of such malevolent events, and on the necessary preparedness and response to deal with them should they occur. I also hope that it will offer a new opportunity to the large number of decision makers and experts attending it, and representing so many countries, to take stock of the new security threats posed by radioactive sources and to decide on renewed international actions and therefore develop suggestions for further action by national authorities and international organizations.

Should this conference reach substantive findings, they would certainly serve as a basis for a renewed action plan for the benefit of the international community.

THE CHALLENGE OF REGULATING WITH BALANCE: NEW SCENARIOS, NEW STRATEGIES?

D. CLEIN
Nuclear Regulatory Authority,
Buenos Aires, Argentina
E-mail: dclein@sede.arn.gov.ar

Abstract

The problem of loss of control over radioactive sources is not new. While radiological risk was considered as the main consequence of loss of control in the past, the possible malevolent use of such sources has been a new threat since 11 September 2001. The Argentine Nuclear Regulatory Authority is taking the necessary steps to prepare for the new challenge within the country and also continues to assist other countries in Latin America. On a global scale, Argentina actively supports the relevant IAEA activities.

On 11 September 2001, a new scenario was played out and within it the awesome possibility that radioactive sources could be used for malevolent purposes to harm and to terrify people.

Ensuring the proper security of radioactive sources is not new for nuclear regulators. It is a basic requirement of international radiation safety standards. It was emphasized at the Conference on the Safety of Radiation Sources and the Security of Radioactive Materials, held in Dijon in 1998, and it was concluded at the Conference of National Regulatory Authorities with Competence in the Safety of Radiation Sources and the Security of Radioactive Materials, held in Buenos Aires in December 2000. On the latter occasion, however, the need was pointed out to differentiate clearly those situations in which sources are unintentionally misused from those where there is a criminal intent to divert sources for malevolent purposes.

The novelty of the new scenario, therefore, is that it includes the malevolent intention of those who could take possession of radioactive sources and their suicidal approach to reaching their goals, increasing the probability of occurrence of such acts and strongly challenging the control system.

Obviously the capability of each country to face this problem depends on its existing control infrastructure. It becomes necessary, then, that each State evaluate critically its control system and take a strategic decision for the future.

As many of you are aware, since the 1950s the use of radioactive sources for peaceful purposes has grown steadily in Argentina. Simultaneously we have developed a control infrastructure based on the knowledge of the risk associated with the deleterious effects of ionizing radiation and on the international philosophy for their assessment and limitation.

The pillars of our system are: scientific knowledge, registration and licensing of radioactive sources and users, and a clear assignment of responsibilities. The system design is based on having permanent information about the location of the sources and ensuring that they are used only in lawful and justified activities.

These basic design criteria, aimed at safety, include the concept of ‘security’ by assigning to the user the responsibility for safekeeping of the source. This principle is enshrined in the text of our National Nuclear Law, promulgated in 1997. When the number of sources in use or in storage is large, as in the case of the Atomic Centres, safekeeping has been assigned to the security forces, but responsibility remains with the owner/user.

We have always understood that there are no national borders for risk and that we should be part of an international effort of protection. In that connection, we have been working for more than twenty years on the education and training of professionals specialized in radiological protection and nuclear safety for the Latin American region. Many of the specialists trained within this framework have formed the core of the national regulatory authorities of the region. These in turn are being strengthened thanks to the initiative taken by the IAEA through its Model Project on Upgrading Radiation Protection Infrastructures in Member States receiving its assistance.

As was said at the conference in Buenos Aires, prevention of criminal acts involving radioactive sources requires broad competence and a thorough understanding of all related aspects, making essential a close co-operation among regulatory authorities and other relevant institutions, such as customs, police and intelligence agencies. In this connection, we have promoted agreements with the relevant national institutions, and we have developed co-operative programmes with them.

The Argentine regulations establish that individuals and organizations authorized to use radioactive sources should prepare contingency plans and procedures for emergencies. The Nuclear Regulatory Authority, ARN, sets up criteria for action in the case of an emergency and evaluates plans and procedures for situations such as the theft or loss of a source, loss of integrity of a shielding structure, fire or explosion.

Within the ARN there is an Intervention System for Radiological Emergencies (ISRE) ready to be implemented in the event of an emergency involving radioactive materials. The intervention group, on duty round the clock the whole year, has the equipment and infrastructure appropriate to take action in a fast and efficient way.

In addition, the ARN has co-operative agreements with the Federal Police, the Border Army (Gendarmería Nacional), the Coastguard, and the Federal Emergency System to co-ordinate actions in the event of a radiological emergency.

In sum, the new scenario does not find us unarmed. However, we cannot ignore the fact that to deal with a situation with such novel malevolent characteristics implies a challenge that demands a change of mentality both in the analysis and in the adoption of regulatory decisions. The issues that arise and the fear that is naturally spawned in the face of the unknown could lead to drastic actions or even to no action at all. Both extremes are harmful for the activity we regulate.

For us it is clear that knowledge is the first line of defence. Such knowledge resides in the national regulatory authorities, who are aware of the deleterious effects of ionizing radiation and of the control measures necessary to limit them.

We believe that, in this scenario, optimization should be the guiding principle for decision making. One must bear in mind that an excess in protective actions is a mistake in itself.

As the situation facing us is a global one, it requires a global response that should arise from a fluid exchange of information among regulatory authorities. The IAEA has without a doubt an important role in the co-ordination of such an exchange. The network of regulatory authorities should be closely linked with the corresponding network of security organizations.

Such a network of protection should generate trust in the public. It is the only guarantee against panic. The most effective way to create confidence is by means of truthful and permanent communication with the public. Of course, this requires a great effort on the part of regulators to convey the message to the public, and it demands from the media an unavoidable commitment to truth and knowledge.

We believe that the path being taken is the right one. However, we should recognize that there exist areas of vulnerability that in the new scenario could facilitate the realization of the potential malevolent actions. Among those vulnerabilities, we can mention orphan sources or insufficiencies in the management of sources no longer in use.

An effective tool to correct these weaknesses is the application, worldwide, of the Code of Conduct on the Safety and Security of Radioactive Sources, an instrument that allows the need for control to be compatible with the feasibility of the lawful uses of radioactive sources.

ENHANCING CONTROL OVER RADIOACTIVE SOURCES: THE FRENCH EXPERIENCE AND INITIATIVE PROPOSALS

A.-C. LACOSTE
Directorate-General for Nuclear Safety and Radiation Protection,
Paris, France
E-mail: andre-claude.lacoste@asn.minefi.gouv.fr

Abstract

The French national regulatory control system for radioactive sources has been in place for more than 50 years and was recently updated. This system relies on a licensing process for the manufacturer, vendor or user of radioactive sources and a registering process of individual sealed radioactive sources. One of the key requirements is for a vendor to recover the sealed sources it has sold. France has the technical capabilities to detect and then secure orphan sources. Emergency preparedness provisions and emergency response teams are in place to deal both with the source itself and also with its consequences for public health. France is willing to organize in the second half of 2004 an international conference on the security of radioactive sources, to review the effectiveness of actions already undertaken or arising from the present conference, and to define any relevant complementary measures.

1. INTRODUCTION

As the head of the French nuclear safety authority (DGSNR), I welcome the opportunity to present a very brief overview of French experience in regulating and dealing with radioactive sources, and French proposals for potential international improvements in these areas.

France has long been aware of the need to maintain control over radioactive sources to protect public health and the environment. A regulatory body dedicated to this goal was established more than 50 years ago. From an international standpoint, France has been promoting a greater awareness of this issue for many years. The Conference on the Safety of Radiation Sources and the Security of Radioactive Materials, held in Dijon in 1998, is a perfect example of a French initiative.

This paper focuses on three topics:

— The French national regulatory system for radioactive sources,
— Dealing with orphan sources and emergencies,
— International initiatives supported by France.

2. FRENCH NATIONAL REGULATORY SYSTEM FOR RADIOACTIVE SOURCES

The French regulatory system for radioactive sources has been in place for 50 years and was recently updated to take into account the 1996 European directive laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionizing radiation.

The system regulates the whole life cycle of a radioactive source, from its manufacture (or import into France) until its disposal (or export out of France). Of course, low risk sources are exempted from this system, as the European directive allows for this.

I wish to emphasize three main features of the French system:

First, it puts into force a licensing process. A licence is required to manufacture, possess, use, sell, import or export radioactive sources, and my organization (DGSNR) issues most of these licences. The licensing process includes the review of basic provisions against source theft (for example the storage of sources in a safe while they are not in use), and the review of the user's source inventory. Provisions designed for radiation safety, such as restriction of access to trained workers, storage in a cabinet or safe of unused sources, or wall shielding, contribute to source security.

Second, sealed source transfers between vendors and users or between users are registered. This registration:

— Allows for the verification that the buyer has the required licence.
— Is an input to a national registry of radioactive sources. The Institute for Radiation Protection and Nuclear Safety (IRSN) is in charge of processing the registration and maintaining the registry.

Third and last, a vendor is required under the law to recover used sealed sources on the request of the user or ten years after the source was first registered. This requirement is designed to limit the potential for sources becoming orphaned.

Furthermore, a draft European directive on the control of high activity sealed radioactive sources, based on the above mentioned principles, is being prepared.

3. DEALING WITH ORPHAN SOURCES AND EMERGENCIES

France owns and operates specific equipment to detect radioactive sources which were never or are no longer under regulatory control. The Atomic Energy Commission (CEA), the IRSN and some private companies have developed capabilities and experience in this field, for example by installing equipment at some border crossings or by performing aerial surveys by helicopter.

Despite the procedures and features in place to prevent them, incidents or accidents involving radioactive sources may occur. France has capabilities for dealing with such accidents and relies firstly on general provisions such as specifically trained fire-fighters located in different areas around the country, and secondly on specialized teams and equipment operated mainly by the CEA and the IRSN. If such an accident compromises worker or public health, internationally known medical experts and facilities are available, and the IAEA has previously used these resources.

4. INTERNATIONAL INITIATIVES SUPPORTED BY FRANCE

France fully supports the IAEA's action plan for strengthening the safety and security of the most dangerous radioactive sources. In particular, the widest application of the Code of Conduct on the Safety and Security of Radioactive Sources, drawn up under IAEA auspices, is and will remain a priority. Actions should be developed within this framework to assist States to establish or strengthen national control systems. It is the responsibility of each State to put the appropriate infrastructure in place for the purpose of controlling the production, distribution and use of radioactive sources.

Although the IAEA's action plan has identified short and medium term actions, additional efforts can still be made. Conscious of the risk represented by the malevolent use of radioactive sources, France wishes to give this issue a specific place within the framework of its chairing of the G8. It considers that actions taken to manage radioactive sources safely and with complete security can be strengthened, complemented and expanded, in both the medium and the long term. The prevention of acts of radiological terrorism is an issue that calls for a collective awareness of this risk, and the introduction of international mechanisms that reinforce international co-operation in this area to support and complement the IAEA's actions.

France therefore suggests that this issue be given political impetus, and proposes the following guidelines:

(a) International action to list the most dangerous sources distributed worldwide, locate them and make them secure, where necessary. More specifically, the IAEA campaigns to locate orphan radioactive sources could be intensified, particularly in the more vulnerable States. This calls for full co-operation between the principal States that have in the past exported powerful radioactive sources, so that these campaigns can be better targeted.

(b) Development in international co-operation towards international commitments on the safety and security of sources, the exact form of which remains to be determined. By way of an example, the principal States producing and exporting radioactive sources (fewer than ten) could make a political commitment to manage the sources they produce properly, both domestically and on export. This commitment could take the form of Guidelines for the Safety and Security of Radioactive Sources, corresponding to the application of certain provisions in the Code of Conduct. The model used could be the Guidelines for the Management of Plutonium drawn up and adopted under the aegis of the IAEA by certain countries holding stocks of that material.

(c) In the longer term, and when the Code of Conduct is widely applied, the IAEA could be entrusted with the task of maintaining a register of the transnational movements of the most dangerous radioactive sources, and of alerting the international community to any anomalies recorded. The information for this register would be provided by the exporting and importing States, using mechanisms still to be defined.

(d) Finally, France, which in 1998 organized the first international conference on the safety and security of radioactive sources, suggests that it organize, in the second half of 2004, what would be the fourth international conference on this subject, after the Dijon conference, the Conference of National Regulatory Authorities with Competence in the Safety of Radiation Sources and the Security of Radioactive Materials, held in Buenos Aires in 2001, and the present conference in Vienna. This 2004 conference would be an opportunity to update the record of action undertaken, and would also allow participants to examine the new guidelines, should the proposals I have just described be adopted.

SECURITY OF RADIOACTIVE SOURCES: JAPANESE PERSPECTIVES

K. HIROSE
Ministry of Education, Culture, Sports, Science and Technology,
Tokyo, Japan
E-mail: khirose@mext.go.jp

Abstract

Radioisotopes have been used in various fields in Japan. The number of users of radioisotopes has increased to about 5000 today. The use of radioisotopes is under regulation by a national law. Measures for security in the regulatory law relate to licensing, physical control, inspection and reports. Since 1958, there have been 66 incidents of lost sources, and a total of 182 sources were not found. Only two cases have occurred of intentional scattering of radioisotopes, and these involved very limited amounts of unsealed radioisotopes. These incidents caused neither danger to life nor damage to property. The safety regulatory system and practice cover the security of such small sources. The vulnerability of radioactive sources is evaluated in the assessment of sources with respect to their radiation hazard, accessibility and portability. It is also required to assess the regulatory system and the operator's measures for managing and securing such sources. The following measures for a system of registration of sources are proposed: (1) To develop a universal system for labelling the sources vulnerable to malevolent use. (2) To incorporate such a universal system for labelling into a regulatory system of registration in each State. (3)To build an international system for registering the sources in the form of cradle to grave management worldwide.

1. CURRENT STATUS OF THE SECURITY OF RADIOACTIVE SOURCES IN JAPAN

Radioisotopes have been used in various fields in Japan. The number of users as of March 2002 was 4788, including 797 medical, 492 educational, 677 research, 1925 industrial and 897 other organizations.

The Law Concerning Prevention of Radiation Hazards is the main regulatory law covering radioactive sources, and the Ministry of Education, Culture, Sports, Science and Technology is the main regulatory authority. According to the law, users must meet a number of measures for security as listed below.

(a) Licensing
- Permission for the use of radioisotopes;
- Restriction of conveyance of radioisotopes.

(b) Physical control
- Installation of locks on all facilities for the use, storage and waste management of radioisotopes;
- Installation of fences at the boundary of the controlled area;
- Restriction of entry to controlled areas.

(c) Inspections and reports
- Periodic regulatory inspections and on-the-spot inspections for identifying and confirming the sources;
- Annual reports of facility management, including inventory of sources.

Since the coming into force of the law, there have been 66 incidents involving a total of 28 917 lost sources. This includes 28 698 sources of 1.85 MBq each of ^{147}Pm that were stolen in 1983 during transport by truck but that were found and recovered several days later. The number of lost sources that were not found is 182, including 92 that were on board an aircraft that crashed in 1985.

2. INCIDENTS OF MALEVOLENT USE OF RADIOACTIVE SOURCES IN JAPAN

Japan has experienced two incidents of intentional scattering of radioisotopes in public places.

Case 1: A worker at a research institute removed an unsealed radioisotope and scattered it at a railway station.
Sources: ^{125}I (100 kBq) for radioimmunoassay.
Date: 20 December 2000.
Place: Japan Railway, Takatsuki Station, Osaka.
Actions by the regulatory authority: Immediate dispatch of duty officers and technical experts to the scene for control of entry, monitoring and cleanup of the area.
Consequences: No health effects on the people concerned.
Suspect: Arrested and confirmed to have a mental problem.

Case 2: A researcher at a university institute removed vials containing unsealed radioisotopes and scattered them in the institute.

Sources: ^{32}P (15.4 MBq × 5), ^{14}C (1.55 MBq × 1).
Date: 23 June 1997.
Place: Genome Information Research Center, Osaka University.
Actions by the regulatory authority: Immediate dispatch of duty officers and technical experts to the scene for control of entry, monitoring and cleanup of the area.
Consequences: No contamination outside the controlled area and no health effects on the people concerned.
Suspect: Arrested.

From these experiences we consider that the real effect of such malevolent uses of small sources is limited, causing temporary social confusion only, and little danger to life and property. Because of the extensive use of small sources in society, it is difficult to control such sources strictly. The safety regulatory system and practice cover measures against the malevolent use of small sources.

3. VULNERABILITY OF RADIOACTIVE SOURCES TO MALEVOLENT USE

We analysed the vulnerability of sources used widely in Japan, and the results are presented in Table I.

TABLE I. VULNERABILITY OF SOURCES TO MALEVOLENT USE

Application of sources	Nuclide	Typical activity of source (TBq)	Radiation hazard	Accessibility	Portability	Vulnerability
Irradiation plant	Co-60	300–400	High	Low	Low	Low
Radiotherapy apparatus	Co-60	0.04–200	High	Medium	Medium	Medium
	Cs-137	40–200	High	Medium	Medium	Medium
	Ir-192	0.4	Low	Medium	High	Medium
Blood irradiator	Cs-137	50–150	High	Medium	Medium	Medium
Industrial radiography apparatus	Ir-192	0.4–4	Low	High	High	High
	Co-60	0.4–4	Low	High	High	High

4. RECOMMENDATIONS FOR FUTURE ACTIVITIES

Vulnerability analysis for sources can be carried out on the basis of the following three factors.

(1) Radiation hazard potential,
(2) Accessibility,
(3) Portability.

On the basis of the result of such an analysis, each government has to assess its regulatory system, and operators have to take measures to manage and secure the sources in accordance with the regulatory system.

We propose the following system of registration of sources. As the first step, we propose that a universal system for labelling the sources vulnerable to malevolent use be developed under close collaboration between manufacturers, regulators and users worldwide. Secondly, we should incorporate such a universal system for labelling the sources into a regulatory system of registration in each State. Finally, we should build an international system for registering the sources in the form of cradle to grave management worldwide.

RADIOLOGICAL TERRORISM: COUNTERMEASURES AND MEASURES FOR MITIGATION OF CONSEQUENCES

A.M. AGAPOV
Department of Safety and Emergency Situations,
Ministry of the Russian Federation for Atomic Energy,
Moscow, Russian Federation
E-mail: agapov@minatom.ru

Abstract

Radioactive sources can be used in devices aimed at radiological terrorism. The paper briefly discusses the types and quantities of sources that may be suitable for such a purpose. A summary of equipment containing significant radioactive sources manufactured in the former Soviet Union is presented. The paper also describes the structure, functions and future directions of activities of organizations in the Russian Federation responsible for nuclear safety and security, including the control and accounting of radioactive materials and the system to prevent, respond to and mitigate the consequences of nuclear emergency situations.

The potential for the use of ionizing radiation sources (IRSs) by terrorists creates certain problems associated with issues such as accountability and monitoring, as well as measures to counteract their illegal transport and use. Using the radioactive substances present in a piece of equipment is one of the possibilities for creating a device aimed at radiological terrorism. As assessments show, industrial isotope sources of Co, Cs, Sr and Pu, which are widely used for defectoscopy, sterilization, medical purposes and independent power sources, can easily be used as the 'filling' of a radiological weapon. It should be noted that the total potential of a radiological weapon using 100–1000 of these isotope sources based upon ^{60}Co, ^{90}Sr or ^{137}Cs will be similar to that of the nuclear waste from a single nuclear power plant cycle.

Creation of the State system of control and accountability of radioactive materials and radioactive wastes began in the Russian Federation in 1998. The Ministry of the Russian Federation for Atomic Energy (Minatom) is the co-ordinator (State contractor) of the work on creation of the State system.

Eighteen departmental and 56 regional centres have been created so far within the framework of the system. These centres interact with over 1500 organizations. Unlike the cases of nuclear power production and the nuclear industry, where the registering system functions successfully, creation of the system for accounting and monitoring of IRSs has not yet been completed in several sectors of the economy and in some regions. Nevertheless, IRSs are widely used in these branches. The medical γ therapy instruments Agat and Krokus, for example, have an estimated ^{60}Co content at the level of 600–800 kCi[1].

The situation is even more serious in the case of radioisotope thermoelectric generators (RTGs, Table I). The total production of sources of this type was about 900 and most of them have by now already exceeded their service life. The total content of ^{90}Sr in the generators is about 45 MCi. Unfortunately, it needs to be noted that the safety assurance system for these sources was designed without taking into account the possibility of unauthorized access to them.

It must be recognized that the accounting and monitoring system and its functions were developed before the current awareness of the potential for a terrorist threat. Therefore the creation of a system for control and accountability of IRSs corresponding to the present threats at both national and

TABLE I. RTGs PRODUCED IN THE FORMER SOVIET UNION

RTG type	Initial rated thermal power (W)	Initial rated activity (10^3 Ci)	Output rated electrical power (W)	Output voltage (V)	Weight (kg)	Start of production
Beta-M	230	35			560	1978
Efir-MA	720	111	30	35	1250	1976
RITEG IEU-1	2200	339	80	24	2500	1976
RITEG IEU-1M	2200 or 3300	340 or 510	120 or 180	28	2 or 3 items, 1050 each	1990
RITEG IEU-2	580	89	14	6	600	1977
RITEG IEU-2M	690	106	20	14	600	1985
Gong	315	49	18	14	600	1983
Gorn	1100	170	60	7, 14 or 28	1050	1983
Senostav	1870	288			1250	1989

[1] 1 Ci = 37 GBq.

international levels is an important element for future work. The most important problem of the system for accounting and monitoring is to prevent the orphaning of radiation sources and to preclude the possibility of the appearance of such sources on the black market.

The technical means for the detection of IRSs and radioactive materials in the basic elements of the transport infrastructure, together with specific systems of radiation monitoring in settlements, should constitute an important part of the safety assurance system. New and effective methods and devices for the detection of radiation sources and hazardous radiological weapon components in public places, in transport facilities, at the entries to cities and on the territory of large industrial facilities should be developed. Precautionary measures to prevent the possibility of the organization of a radiological terrorist attack should be the main objective of the system. A correction of the current system of State management in the provision of radiation safety in the Russian Federation may be required. The components of the present system are:

— Identification of hazardous facilities;
— Registering of hazardous facilities;
— Monitoring and supervision;
— Responsibility of organizations, accountability;
— Economic mechanisms, insurance, inventory commissions;
— Training and certification of personnel;
— Safety expertise, probabilistic safety analysis and risk assessment;
— Legal regulation, standardization;
— Acceptance of operating organizations;
— Licensing of activities;
— Certification;
— Registration of State orders and federal programmes;
— Emergency response;
— Recording and investigation of accidents;
— Prevention and mitigation of the consequences of accidents.

Specialists from Minatom together with scientists from the Russian Academy of Sciences and the Ministry of Health are working on a systems analysis of possible consequences of terrorist attacks with the use of IRSs and radioactive materials. Special attention is being paid to developing models, methods and practical recommendations aimed mainly at:

(a) Adequate description of possible methods of dispersing radionuclides depending on their physical and chemical characteristics in the radiation source;

(b) Development of modern computer codes describing processes of spreading radioactive substances in urban conditions;
(c) Definition of the factors that have the greatest effect and of critical population groups which require first-priority protective measures;
(d) Prediction of the dynamics of acute and long term effects of radiation on the population, and development of a prediction of the medical consequences of a radiological attack.

Examination of the widest possible spectrum of potential terrorist attacks with radiological consequences is necessary. This would include: the exploding of radioisotope sources or other means of spreading them in the atmosphere, contamination of the transport system (roads, underground systems, railroads, etc.) and contamination of surface waters or water supplies.

It is advisable to select and assess the most important contamination parameters (for example, distances over which contamination is reduced by a factor of 100 and 1000 in the case of contamination of the transport system) for each of the above mentioned situations and for various radionuclide compositions. Also, the protective measures should be assessed and the most effective ones recommended. This work is aimed at ranking the potential threats and the measures for their minimization, and also at development of special computer systems for provision of expert scientific and technical support to provide an optimal response to terrorist attacks using radioactive substances.

Analysis of the situation in the Russian Federation shows that the existing response systems developed for the case of a radiological accident (and which function effectively in such a case) are not quite suitable for adequate response to acts of radiological terrorism or for simulation of such events. Therefore the scientific research and studies aimed at improving the response system and at elaborating recommendations for the optimization of a strategy of protective measures are of primary importance. The basic ideas of 'substantiation' and 'optimization' principles of intervention in the case of radiological accidents and incidents, accepted internationally, should be introduced into the Russian system of emergency response more clearly. All relevant concepts should be applied to the problems of mitigation of the consequences of acts of radiological terrorism. It should be clear for decision makers at all levels that the planned protective measures must bring to society, and above all to the people directly affected, more benefit than harm. The form, scale and duration of the intervention should be optimized from the point of view of obtaining maximum benefit.

An efficient means of increasing preparedness for an emergency at a nuclear power plant is to carry out training, drills and exercises. Such measures can be divided into:

— Exercises involving specialists from separate departments and crisis centres aimed at testing the specific functions of these units;
— Exercises testing the interaction between crisis centres of various types and between crisis centres and individual departments, for example the military;
— Exercises involving all or most structures of the emergency response system.

Exercises and drills are aimed mainly at testing the functioning of operational personnel and administration in the case of emergency situations and the interaction between the resources of the facility and organizations involved. Exercises are also aimed at the organization of protection of the public and at testing the interaction between the Centre for Emergency Situation Control, regional centres, bodies of executive authorities and teams of experts. Also of great interest are international exercises that include both training of national services and testing of co-operation in the provision of urgent assistance in the event of an emergency with cross-border radiological consequences.

The development of computer systems for training is considered to be an important part of this work. These systems should be developed for the training and education of specialists in the assessment of the radiological situation in contaminated territories.

Such training systems should also be able to simulate in a real time mode the radiological situation on-site in the event of a terrorist attack with the use of radioactive materials. It is advisable to develop both stationary and field modifications of the system. Such systems can be realized for separate territories and facilities.

It is necessary to remember that decision making following a radiological terrorist attack should take into account not only the direct radiological and medical consequences but also indirect consequences, which include psychological, social, economic and political consequences.

The perception of radiation risks that has developed around the world, in combination with the wide availability of modern meters for the detection of excess radiation background, leads to huge indirect negative consequences (psychological harm and stress; economic, social and political consequences) even in the case of a minor effect on the environment and on health. Such an inappropriate attitude towards the possible consequences of a radiological terrorist attack and the direct and indirect losses connected with them has a historical and psychological background. It is also a consequence of the distorted information received by nearly all social groups about the real levels of radiation risks (Hiroshima, Nagasaki, Chernobyl, South Urals, etc.).

Therefore it is necessary to carry out active work with society, mass media representatives and leaders at various levels to develop an impartial attitude towards radiation risks. Consolidation of the efforts of specialists in various countries in this area is absolutely necessary.

Work should be done on upgrading the legal and normative basis regulating the safety of radiation sources that could potentially be used for a terrorist threat. Direct transfer of the criteria and normative basis developed and effectively used for the purpose of protection of the public in the event of a radiological accident or incident at a facility of the nuclear industry to situations connected with radiological terrorism is incorrect. The development of additional criteria is required for the substantiation of corresponding standards related to radiological terrorism.

To generalize, we would like to point out the directions important from our point of view to counteract and mitigate the possible consequences of radiological terrorist attacks:

(1) Realization of specific programmes to achieve control of IRSs, including measures for their physical protection and organization of their safe disposal once they are no longer in use. Primarily this refers to the orphan sources.
(2) Upgrading of national systems of registering and monitoring IRSs, especially in non-nuclear industry. Organization of an international system for exchange of information on the registering and monitoring of radioactive substances.
(3) Work on systems analysis of the possibility of realization of various scenarios, and on developing a realistic assessment of their direct and indirect consequences. Elaboration of recommendations on primary measures for the prevention and mitigation of the consequences of these scenarios.
(4) Modernization of the existing response systems for the purposes of protection of the public in the event of radiological terrorism.
(5) Development of special programmes and technical means for the purposes of source detection and decision making support.
(6) Improvement of the normative and legal basis regulating all aspects of the use of radiation sources in the national economy.
(7) Development of scientifically substantiated criteria for the creation of standards of environmental contamination and dose limits for the population which require the implementation of urgent, medium term and long term measures in the event of a terrorist attack with the use of radioactive sources.
(8) Fostering of an impartial attitude on the part of the public, specialists, leaders at various levels and media representatives towards radiation

risks. This lays an important foundation for increasing the protection of the public from the threat of radiological terrorism and the capability of society to overcome the consequences of such acts with minimal losses.

The realization of the complex work needed in these directions will allow a dramatic decrease of the possibility of radiological terrorist attacks and mitigation of their possible direct and indirect consequences. Success in this field can be reached only by consolidation of the efforts of specialists in various countries and international organizations within the framework of bilateral and multilateral programmes, including those under the aegis of the IAEA. The Russian Federation and the USA have already made the first steps in the organization of such co-operation.

GLOBAL SECURITY OF RADIOACTIVE SOURCES: THE SOUTH AFRICAN PERSPECTIVE

L. ZONDO
National Nuclear Regulator,
Centurion, South Africa
E-mail: lzondo@nnr.co.za

Abstract

The paper summarizes the perspective of South Africa on a number of issues relating to the security of radioactive sources, including manufacture, regulatory control and security, vulnerabilities and orphan sources, and information confidentiality. The paper also presents conclusions and recommendations from a South African viewpoint.

1. INTRODUCTION

Highly radioactive sources are used in everyday life. This is the biggest challenge. Globally, radioactive sources have been widely used for decades to benefit humankind. They are used to treat cancer patients, as irradiators to preserve food, in industrial radiography to check for welding defects in pipelines and buildings, for thermoelectric generation of electricity in remote locations and for a variety of other uses.

No good figures exist on how many radioactive sources exist worldwide, but there are reportedly some 10 000 radiotherapy cancer treatment units worldwide, with many more radioactive sources used throughout industry. Some of the radioactive isotopes that cause most concern to security officials are ^{60}Co, ^{90}Sr, ^{137}Cs and ^{192}Ir. The huge number of applications of these materials makes it a big challenge to track and control them even with our best efforts. Radiological sources are essential to our societies and we have no choice but to seek pragmatic solutions to secure and control every item, everywhere, in a quest to balance benefit and safety. Many of these sources are lost, stolen or simply abandoned when no longer required.

South Africa is supportive of the IAEA's Code of Conduct on the Safety and Security of Radioactive Sources, which seeks to prevent the loss of or unauthorized access to radioactive sources through the establishment of an effective system of regulatory control from the production of radioactive sources to their final disposal. It also calls for a system to restore such control if a source has been lost or stolen.

This paper summarizes the perspective of South Africa on a number of issues relating to the security of radioactive sources, including manufacture, regulatory control and security, vulnerabilities and orphan sources, and information confidentiality. The paper ends with conclusions and recommendations from a South African viewpoint that would contribute towards taking the issue forward.

2. SOUTH AFRICAN PERSPECTIVE

2.1. Manufacture and distribution of sources

South Africa is in a fortunate position in that radioactive sources are manufactured in one facility for the whole country and for export. The South African Nuclear Energy Corporation (NECSA), through its business division, Nuclear Technology Products (NTP), produces a variety of radioactive sources. NTP's products are produced to internationally approved standards and under ISO 9002 certification. The categories of NTP products relevant to this conference are shown in Table I.

Other sources used in South Africa are stationary sources used in industrial irradiators, for example ^{60}Co sources used in food irradiation plants.

NTP production facilities have other international certifications in addition to ISO 9002. For instance, the radiochemical production facilities have United States Food and Drug Administration as well as Australian Therapeutic Goods Administration appraisal. Environmental management is maintained according to ISO 14000 guidelines.

South Africa uses sources internally and also has a large export component. As regards distribution, while NECSA undertakes direct

TABLE I. CATEGORIES OF RADIOACTIVE SOURCES MANUFACTURED AT NECSA

Product category	Example
Sources used in public access facilities (radiopharmaceuticals)	Tc-99m, I-131
Sources used in public areas (well logging or pipeline radiography, radiochemical products)	Ir-192, Cs-137, Co-60, Mo-99, P-32, I-131

distribution internationally, it also has business arrangements to distribute to customers through a South African company.

South Africa has a storage facility at NECSA for spent sealed sources. The country is currently finalizing a national waste policy and strategy that will address issues of disposal. The current situation with NECSA is satisfactorily managed.

2.2. Regulatory control and security

According to South African legislation, the Directorate Radiation Control under the Department of Health and the National Nuclear Regulator have the responsibilities for exercising regulatory control over radioactive sources.

According to the Hazardous Substance Act (Act 15 of 1972), 'Group IV hazardous substance' means a radioactive material which is outside a nuclear installation, and is not a material which forms part of or is used or intended to be used in the nuclear fuel cycle, and

(a) Has an activity concentration of more than 100 Bq/g and a total activity of more than 4000 Bq; or
(b) Has an activity concentration of 100 Bq or less per gram or a total activity of 4000 Bq or less and which the Minister of Health has by notice in the Gazette declared to be a Group IV hazardous substance, and which is used or intended to be used for medical, scientific, agricultural, commercial or industrial purposes, and any radioactive waste arising from such radioactive material.

The Directorate Radiation Control has the responsibility for regulatory control over Group IV hazardous substances.

According to the National Nuclear Regulator Act (Act 47 of 1999), however, the National Nuclear Regulator has responsibility with respect to a radioactive source when it is within a nuclear installation site.

For more effective monitoring and control of radioactive material, the National Nuclear Regulator Act requires the National Nuclear Regulator to enter into co-operative governance agreements with all organs of State that have responsibilities over radioactive materials, for the purpose of co-ordinating functions, minimizing duplication and promoting consistency. To this effect the Directorate Radiation Control and the National Nuclear Regulator co-operate in the regulatory control of radioactive sources.

South Africa's regulatory practices are in line with international standards and requirements.

With regard to security, the regulatory bodies work in close co-operation with security agencies through the National Intelligence Agency (NIA), which has a statutory responsibility to protect the interests of the State. Co-operation with the security agencies addresses the issues of theft and loss of radioactive sources.

2.3. Vulnerabilities and orphan sources

South Africa recognizes that there are many situations and scenarios both nationally and internationally that may result in vulnerabilities and consequently the need to heighten and strengthen regulatory control, especially compliance assurance, quality assurance and enforcement. Weaknesses in these areas may contribute to radioactive sources posing a serious threat globally.

The South African Government is committed to ensuring that the security of radioactive sources is improved both within South Africa and internationally. South Africa has participated in and contributed to IAEA processes and other international forums to improve the control and management of radioactive sources internationally, and mainly in Africa.

Sealed radioactive sources have been and still are used widely in Africa; for instance, ^{226}Ra was used extensively during the early years (1950s and 1960s) for treatment of various cancers. These sources were generally imported from European countries and other international suppliers. There were always challenges with regard to arrangements for the return of these sources to the original owners. Often after falling into disuse they were stored somewhere inside the facility in which they were used, sometimes next to a patient waiting room, and of course this resulted in unacceptably high levels of exposure to patients.

Another problem with the radium sources and also with other spent sources is that in many instances few or no records existed, making it an even bigger challenge to control all the spent sources properly. Some African countries, however, have managed to collect the sources from the different storage places and put them into one central storage place. It is these countries that have applied to the IAEA through AFRA processes for assistance for the radium sources to be conditioned. The South African team responsible for conditioning radium sources in Africa has to date conditioned radium and other spent sources in ten African countries. After conditioning, these sources are stored under proper control for later disposal. A total of more than 3000 mg of ^{226}Ra has been conditioned in this manner so far.

South Africa has processes to ensure that orphan sources when discovered are reported and that the necessary steps are undertaken to place such sources in appropriate storage. The Directorate Radiation Control records that there are approximately 22 000 sealed and unsealed sources in South Africa. South Africa supports a cradle to grave approach to regulation.

2.4. Public information and confidentiality

Like any other sovereign State in the modern world, the Republic of South Africa has to serve and protect its own interests. In a democratic and open society committed to transparency, the need for secrecy and thus information security must realistically match the threats against the country and its people. The South African NIA has a statutory responsibility to protect the interests of the State. With this imperative in mind, the NIA as well as other members of the intelligence community have focused their attention on the process used to formulate and implement information security policies on a national basis within South Africa.

Like most democratic countries, South Africa is faced with the challenge of making information available to the public. While the Promotion of Access to Public Information Act further entrenches the right of the public to information, it also provides for appropriate information to be given to the public. Through the provisions of this Act, South Africa is able to screen information so that information that is commercially sensitive or sensitive with respect to national and international security can be disseminated appropriately and to the relevant people. In addition, information security in South Africa is administered in accordance with the Minimum Information Security Standard, which was approved by the Cabinet on 4 December 1996 as the national information security policy.

3. RECOMMENDATIONS AND CONCLUSIONS

The nuclear industry is home to, amongst others, scientists, technicians and artisans — in most cases people interested in science and technology — and unfortunately there remains a dire need to advance public awareness of issues relating to this industry, which has so much potential for contributing to solving the world energy lust. For improved public acceptance and involvement of the needed expertise, the nuclear industry is dependent on there being properly sensitized media that report in a constructive manner the events happening in the industry.

Efforts directed at educating the media as a priority for more effective public education and information are of vital importance for any industry, and more so in the nuclear industry.

South Africa supports a number of initiatives that would go a long way towards improving the security of radioactive sources globally. Some of these initiatives include:

(a) Fast tracking the development of activities that make the return of a source to the supplier more feasible;
(b) Increased focus on regional and international co-operation on source conditioning and disposal;
(c) Continued support for borehole disposal issues such as technical know-how, economic aspects, site selection, safety and feedback from the current Technical Co-operation project in Africa;
(d) Discussions on mechanisms of international direct assistance;
(e) Strengthening of regulatory infrastructure in all countries and especially in developing countries.

The Borehole Disposal Concept currently being developed by South Africa is viewed as a viable option for the future. While several IAEA Member States, including the Russian Federation, the USA and many others, have utilized the concept in one way or another, the current South African project is attempting to demonstrate the economic, technical and safety aspects of the concept to be used in developing countries. This option appears attractive for solving the problem in many developing countries.

It is not an illusion that radioactive sources pose a threat to all. South Africa supports attempts to find appropriate and humane options to address this problem at national and international levels. It is our hope that international forums will continue to increase efforts to support Africa, and developing countries in general, in improving the situation of control over radioactive sources.

KEY UNITED STATES PROGRAMMES FOR THE SECURITY OF RADIOACTIVE SOURCES

D. HUIZENGA
National Nuclear Security Agency,
United States Department of Energy,
Washington, D.C.,
United States of America
E-mail: david.huizenga@nnsa.doe.gov

Abstract

The paper discusses key US programme activities related to the security of radioactive sources, including both domestic and international programmes; the US Department of Energy–Nuclear Regulatory Commission joint report and findings; and critical partnerships for future efforts to preclude terrorist attacks using radioactive sources.

1. INTRODUCTION

As US Secretary of Energy Abraham highlighted in his opening remarks, this conference has brought together over 600 members of the international community, together representing over 110 different countries, to address a new kind of threat — one that demands both national and international action. Many of the participants at this conference have been focused on the health, safety and waste management aspects of sealed sources for many years. Until recently, it was not clear that we would have to gather together at this kind of conference to focus additionally on securing these materials.

2. SUMMARY: WHAT WE MUST DO

The protection of the hundreds of thousands of radioactive sources in use worldwide for beneficial medical, industrial, agricultural and research applications presents a great challenge. Protecting each and every radiological source from terrorist theft is impossible, and impracticable. However, I believe it is possible to protect the radioactive sources that are of greatest concern. As a first step, it will be necessary for States to identify those radiological sources that, in terms of potential lethality, accessibility and dispersability, pose the greatest risk of malevolent use, and command the most immediate attention of all members of the international community. Secondly, States must adopt a comprehensive national plan of action to address the key aspects of the problem, in a sense one might say a ‘cradle to grave’ approach to controlling radioactive sources.

This conference will afford us the opportunity to work together to improve the security of high risk radiological sources worldwide, both at home and abroad. It presents an excellent forum for examining the lessons learned from our domestic, bilateral and multilateral work so that we collectively improve the security, control and regulations regarding the use of radiological materials.

3. UNITED STATES PROGRAMME ACTIVITIES

Let me briefly discuss several programmes that address how the USA is protecting itself from potential radiological threats. We are looking at the problem in layers and have established programmes that focus on strengthening the control and accountability of nuclear and other radiological materials at home, improving the physical security and safe management of materials and facilities at home and abroad, and preventing illicit trafficking by improving border security.

3.1. Domestic programmes

Domestically, the US Government is working to improve the security of radioactive sources. The US Nuclear Regulatory Commission (NRC) and its Agreement States have regulatory jurisdiction over most radioactive sources used domestically. The NRC is in the process of developing interim compensatory measures (ICMs) to be implemented in 2003 and rulemaking changes to be implemented over the next two years to increase the security of high risk radioactive sources. These initiatives will include imports and exports.

The US Department of Energy (DOE) manages large nuclear research and manufacturing facilities. Our national laboratories offer unique isotope production and separation facilities such as reactors, associated hot cells, accelerators and calutrons. Over the years, the DOE has produced and sold many stable and radioactive isotopes that are widely used by domestic and international customers for medicine, industry and research.

Drawing on this experience, the DOE has also for many years worked with the NRC to secure orphaned and abandoned sources. To address these emerging situations as well as planned recoveries, the DOE operates the Off-Site Source

Recovery Program (OSRP) to recover and store certain excess and unwanted radioactive sources from NRC licensees. Indeed, the NRC receives on average one call every day reporting a lost, stolen or abandoned source. Thankfully, not all calls for assistance are for conditions this severe. Thus far, the programme has recovered ^{241}Am and ^{238}Pu sources which were largely used in the well logging industry, portable gauges and medical equipment. The DOE is reviewing plans to expand the programme to take back other isotopes, including ^{239}Pu and ^{90}Sr. Up to the end of Fiscal Year 2002, this programme had recovered over 4000 high activity sources, and it recovered an additional 1000 sources in the first quarter of Fiscal Year 2003. The DOE is on track to recover 5000 such sources over the next 18 months. Licensees contact the OSRP, and the OSRP takes the information provided and uses criteria provided by the NRC and DOE to determine the priority for recovery. In some instances, state regulatory agencies or licensees directly notify the DOE recovery programme of sources.

3.2. DOE–NRC joint report and findings

In addition to the activities just described, the DOE and NRC will soon publish a joint report that evaluates the security of sources in the USA. The areas reviewed by the report include: identifying the radioactive materials of greatest concern, tracking and inventorying radiological sources, tagging and monitoring radiological sources, and dispositioning unsecure radiological sources. The study will make recommendations in each of these areas to improve the security of sources in the USA. In addition, the report provides a basis for identifying the radioactive materials of greatest concern, including criteria associated with contamination, denial of use, and the availability and usability of sources. The recommendations will include:

(a) Near term development of a US tracking system for the sealed sources of greatest concern.
(b) Establishment of action levels for specific isotopes of concern, including requiring that licensees provide increased security over particularly high risk sources or that the DOE take action in recovering and storing a source after its useful lifetime.
(c) Actions to ensure life cycle planning for the secure disposition of unsecured, excess and unwanted sources. The DOE has recently initiated necessary policy analyses that will result in decisions on development of domestic sealed source disposal capabilities. We plan to complete our review of options and our environmental review within the next two years.

3.3. International programmes

Outside the USA, the DOE Office of International Materials Protection and Cooperation is assisting foreign governments and international organizations to improve the security, control and regulations on the use of radiological materials, in order to reduce the risk that terrorist groups could use these materials in an attack with a radiological dispersal device (RDD). Our programme strategy consists of several key elements.

First, we are working to deny access to dangerous and vulnerable radioactive materials through bilateral and multilateral co-operative programmes, including security upgrades at sites in foreign countries with undersecured radioactive sources, and activities to consolidate and dispose of orphan and unwanted sources. We have adopted a risk based approach to focus on high risk sources that represent the greatest potential threat. Examples of facilities that may contain these high risk sources include sterilization and research facilities (e.g. agricultural, medical and nuclear), isotope production facilities at reactors, oncology clinics and nuclear waste repositories, to name but a few.

More specifically, the DOE is working with our colleagues A.M. Agapov, of the Ministry of the Russian Federation for Atomic Energy (Minatom), and A.J. González, of the IAEA, to secure lost, stolen and abandoned radioactive sources on the territory of the former Soviet Union. The purpose of this initiative — called the Tripartite Initiative — is to locate and secure dangerous orphaned and abandoned sources. To date, we have worked in many countries, including Georgia, the Republic of Moldova, Tajikistan, Uzbekistan and others. As the US Secretary of Energy announced in his opening remarks, we are prepared to establish a global partnership for source security which builds on the successful model of the Tripartite Initiative, and we look forward to collaborating closely with the IAEA, its Member States and other States to implement high priority security upgrades where the need is the greatest. Our initial emphasis will be in developing countries.

We also initiated a bilateral project in the Russian Federation to recover and secure orphaned radioisotope thermoelectric generators (known as RTGs). These generators use powerful ^{90}Sr sources to generate electricity for lighthouses and beacons in remote areas. There are almost 1000 RTGs involved. We are working with Minatom to recover and secure these powerful radioactive sources at numerous locations in the Russian Federation. Additionally, we are working with the Russian Ministry of Construction to install rapid physical protection upgrades at radioactive waste repositories in the Russian Federation known as RADON sites. RADON sites handle low and medium level radioactive wastes, including sealed sources containing some highly attractive isotopes. There are 35 RADON sites on the territory of the former Soviet Union, including 16 located in the Russian Federation. We expect to expand our efforts at RADON sites to those located outside the Russian Federation as well.

Since securing all sources is an impossible task, and even those that pose the highest risk will take some time to secure, we must accept the fact that terrorists may acquire radioactive materials and attempt to transport them to targets. Our response to this threat is to provide 'defence in depth' with enhanced radiation detection at border crossings and major transit and transportation hubs. Our experience, in partnership with Russian customs authorities, has reinforced our ability to detect most nuclear and radioactive materials in transit. We are now in the process of accelerating these efforts by installing radiation detection equipment at 20 additional strategic transit and border sites in the Russian Federation by the end of 2003. Installation work in Central Asia and the Caucasus is under way.

We are also working closely with the US Department of State in support of a variety of export control and border security efforts. The USA has begun to work with other countries to develop and implement denial and detection/interdiction strategies. Under this programme, a number of additional countries of the former Soviet Union and Europe are being equipped with radiation portal monitors at key border crossings. These efforts include X ray vans for use at airports to detect radioactive material and to image possible shielded sources in luggage.

Finally, as Secretary Abraham announced, we will now also partner with US Customs to support Customs' Container Security Initiative at megaports around the world, thus reducing the risk of terrorists utilizing the international shipping system to successfully deliver an RDD through use of the vast global container shipping network.

3.4. Next steps: Leveraging critical partnerships

Having established a framework for bilateral and multilateral co-operation, our next steps are to involve more sites and more countries. This is why leveraging critical partnerships with the IAEA and other international agencies, such as the International Criminal Police Organization, and with other countries is key to ensuring that regulations and radiological source control practices are updated to prevent the theft or diversion of foreign origin radioactive source materials for malevolent use.

As Secretary Abraham stated, a key international partner in efforts to secure radiological materials is the IAEA. The USA has been supportive of the Director General's Action Plan for Preventing Nuclear Terrorism. Along with almost 20 other States, the USA has made substantial contributions to the Nuclear Security Fund to support the programme's first year. At the September 2002 General Conference, Secretary Abraham announced an additional US $3 million contribution directed towards securing radioactive sources through strengthening regulations and standards, locating unsecured sources, providing training, and providing detection and response advisory services in the event of a radiological attack. Today we committed an additional US $3 million over the next year to support the Radiological Security Partnership. I would urge all States to contribute to this effort, as resources need to be committed on a regular, long term basis, and all of us must be prepared to work with the IAEA and other international partners to develop long term solutions to these problems.

While responsibility for controlling and securing radiological sources has been and will remain a national responsibility, the international community has an important role to play. The IAEA can help ensure that countries have the proper guidance and the technical resources to properly secure and protect radioactive sources. The international community can also ensure that countries have sufficient resources at their disposal to address the problem. Another area for continued international co-operation is the development of a common set of guidelines to help countries develop an appropriate framework for regulating the safety and security of these sources.

In this regard, the USA continues to support well established programmes such as the Model Project for Upgrading Radiation Protection Infrastructure, a programme that links IAEA assistance with radioactive sources to the completion of milestones in developing the nuclear regulatory infrastructure. We also support the continued review and strengthening of the Code of Conduct on the Safety and Security of Radioactive Sources. The Code of Conduct, once finished and approved, will provide a set of guidelines for States developing national programmes for effective cradle to grave control of radioactive sources.

Finally, let us not forget the important role industry can and must play in helping us solve the problem. As radiological source materials are used widely in global commerce, governments need to work with radiological source manufacturers and suppliers. Options that should be considered include introducing more RDD resistant source materials and forms, improving source control and handling procedures, and closing the source material life cycles by recycling or properly disposing of used materials. Some manufacturers and suppliers have already volunteered to help us address the problem, and we believe many others are likely to co-operate. We have just recently participated in the European Nuclear Society's annual meeting on research reactors and we called upon their support to initiate an effort to work directly with the isotope producers to find economical and sustainable alternatives to certain source materials.

4. CONCLUDING REMARKS

While much hard work has gone into establishing the framework that I have outlined for addressing the radiological terrorism threat, it is only a beginning, and much more needs to be done. Radiological terrorism has no national boundaries. No country is immune to the threat, and no country can ignore the problems without putting itself at risk. While international assistance is important, we must all do our part in solving this problem. This will require a long term political commitment from each and every one of our countries to develop a national action plan to keep radioactive materials located on their soil safe and secure. I use the term ‘we’ because we are all in this together. We have a mutual stake in averting a future RDD incident.

Although it remains to be seen if it is possible to preclude terrorist attacks using RDDs, through our collective efforts it is certainly possible to diminish the likelihood of an attack that has major consequences. The USA is committed to working with the IAEA and with the international community to undertake domestic, bilateral and multilateral activities to reduce the risk that radiological sources could fall into the hands of terrorists.

I am pleased that this conference is exploring these and other means of upgrading our nuclear and radiological security by bringing together experts and policy makers from around the world.

IDENTIFYING, SEARCHING FOR, RECOVERING AND SECURING HIGH RISK, VULNERABLE RADIOACTIVE SOURCES

(Topical Session 1)

Chairpersons

A. Gutsalov
Russian Federation

B. Dodd
IAEA

EXPERIENCE OF EXISTING SECURITY ARRANGEMENTS FOR RADIOACTIVE SOURCES

J.R. CROFT
National Radiological Protection Board,
Chilton, Didcot, Oxfordshire,
United Kingdom
E-mail: john.croft@nrpb.org

Abstract

Even prior to the terrorist attacks of 11 September 2001, it was clear that there was a significant orphan source issue arising from poor safety and security of radioactive materials around the world. The objective of the paper is to globally review, through a series of examples, the variable state of the existing source security arrangements and some of the driving forces and consequences. This provides a background against which the scale and profile of the threats can be developed, along with strategies to address the issue.

1. INTRODUCTION

The radiological accident in Goiânia, Brazil, in 1987 [1] provided something of a wake-up call on the potential serious consequences that can arise from the loss of control of radioactive sources. One of the positive outcomes from that accident was the issuing by the IAEA of a series of publications reporting the investigation of accidents and identifying lessons to be learned [1–11]. Sadly, many accidents are still either not reported in the open literature or in some cases not even recognized.

Over the years following the accident in Goiânia, there was an increasing stream of reports of sources ending up either in the metal recycling industry, with serious economic consequences from smelting of the sources [12], or in the public domain, resulting in serious deterministic effects and in environmental and socioeconomic impacts. The IAEA found that a key root cause was the lack in many countries of an effective regulatory infrastructure and of adequate radiological protection expertise. To address this, the IAEA developed the Model Project on Upgrading Radiation Protection Infrastructure [13], and whilst there is clear progress, there is much to do.

The various issues were brought into focus in the International Conference on the Safety of Radiation Sources and Security of Radioactive

Materials, held in Dijon in 1998 [14]. Arising from this was the development of the IAEA's Action Plan to address the issues [15]. The term orphan source came into common usage, being defined as "a source which poses sufficient radiological hazard to warrant regulatory control but is not under regulatory control, either because it never has been under regulatory control or because it has been abandoned, lost, misplaced, stolen or transferred without proper authorization".

As part of its Action Plan to address orphan source issues, the IAEA had initiated before 11 September 2001 the drafting of a document on National Strategies for the Detection and Location of Orphan Sources and their Subsequent Management. The draft document finds that, in order to develop such national strategies, there is first a need to identify the scale and profile of the threat — in essence what is out there already and what are the routes by which sources become orphan sources.

Thus even before the tragic act of terrorism of 11 September 2001 there was the significant issue of orphan sources to address. On this we now have to overlay the serious potential for terrorists to malevolently acquire radioactive materials and use them in some form of improvised radiological device.

The objective of this paper is to globally review, through a series of examples, the variable state of the existing source security arrangements and some of the driving forces and consequences. This will provide a background against which later papers in this session will develop the scale and profile of the threats, along with strategies to address the issue. The paper draws on relevant parts of the draft National Strategies document mentioned above.

2. OVERVIEW OF ORPHAN SOURCE THREAT

Figure 1 provides a schematic representation of the sources of information that may be important to a country assessing the threats from current orphan sources or situations that could give rise to them.

Later papers in this session will cover issues related to prioritizing efforts to address these threats, e.g. locating and recovering sources, and waste disposal issues. The main focus of this paper will be to look at some of the challenges to the security of sources during their cradle to grave life cycle. However, before moving on, a few observations are appropriate.

(a) The importance of each element in Fig. 1 will vary depending on the circumstances of the country, e.g. a mature or embryonic regulatory system, the historic political stability of the country, the status of situations in neighbouring countries and trading partners.

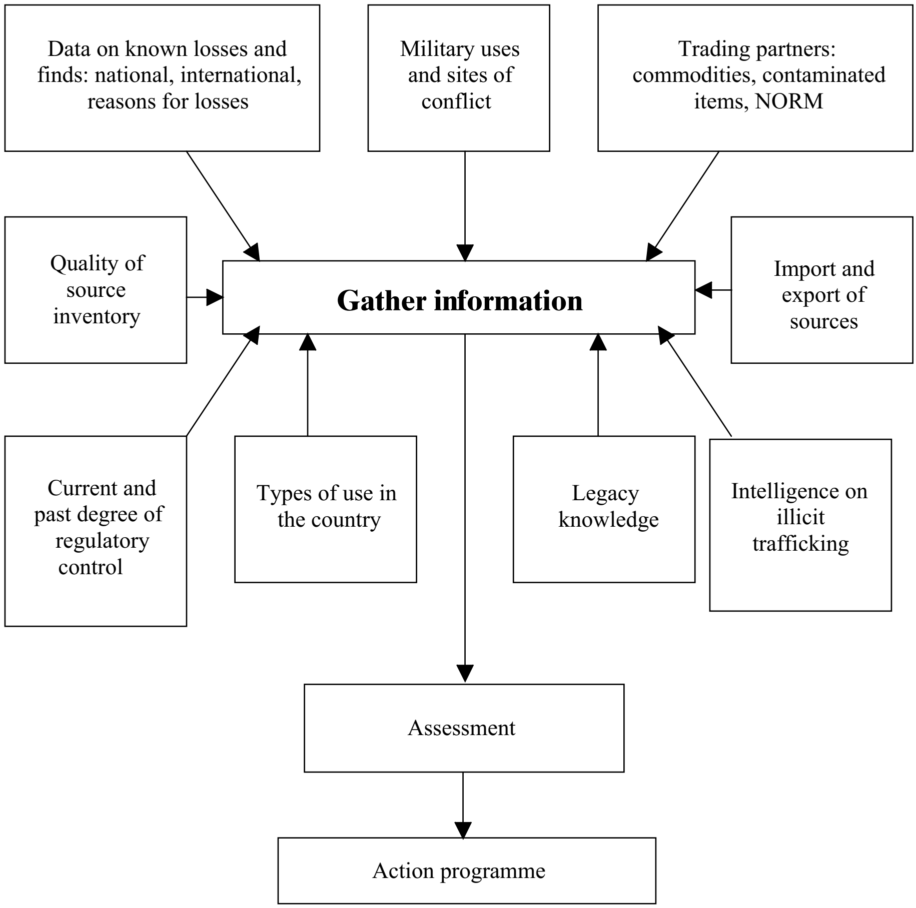

FIG. 1. Assessing the threat from orphan sources. NORM: naturally occurring radioactive material.

(b) Legacy sources are those that predate effective regulatory requirements and may not have been disposed of, or were not disposed of in an appropriate manner. A common example is that of old radium sources used in research or medical environments. In some countries legacy sources may be a substantial problem.

(c) In many countries military uses of radioactive sources were, and often still are, outside the civilian regulatory infrastructure to some degree. These uses should not be overlooked when assessing the security measures. Whilst many of the uses are similar to those found in industry, research and medicine, there are some uses that may be unique to the military or that employ significantly larger activities than those found in comparable non-military devices. The use of radioisotope thermoelectric generators (RTGs) is an important example which will be one focus of the United States of America–Russian Federation–IAEA Tripartite Initiative. RTGs could typically incorporate of the order of a PBq of ^{90}Sr. A number have been found in the public domain. For example, following the discovery of radiation injuries to two members of the public in Georgia, two RTGs were located and recovered in early 2002.

(d) Sites of conflict, almost by definition, bring the potential for some form of breakdown in the chain of control of the security of radioactive sources. Collateral damage caused by shells, bombs and other munitions may involve damage to the radiation sources themselves or to the facilities in which they are housed. This can result in the abandonment of the facilities or sources, making it possible for people to gain access to them or to scavenge them.

  (i) Almost half of the territory of Croatia was affected by war from July 1991 to September 1995. The collateral damage was significant. A range of industrial sources of GBq levels of activity were affected: 18 were recovered in a cleanup programme but 24 remained unaccounted for. Some 60 'lightning preventers', each containing GBq quantities of ^{226}Ra, were also recovered from the rubble of demolished buildings.

  (ii) In 1992 an IAEA mission to Beirut, Lebanon, discovered in a conflict ravaged derelict hospital two radiotherapy sources similar to those involved in the Goiânia accident (~50 TBq ^{137}Cs).

3. FROM CRADLE TO GRAVE

3.1. Full life cycle

Figure 2 provides a simple overview of the full life cycle of sources.

Reactor facilities for the major production of radioisotopes are limited to a small number of countries: Argentina, Belgium, Canada, France, the Netherlands, the Russian Federation, South Africa and the USA [16]. These are largely under direct government control and hence can be the subject of focused security measures. The same is true for radioactive source manufacturers. However, there are a large number of equipment manufacturers who incorporate radioactive sources into their equipment before dispatching it to customers. The equipment manufacturers are diverse, and it would be prudent to treat them as being subject to the same challenges

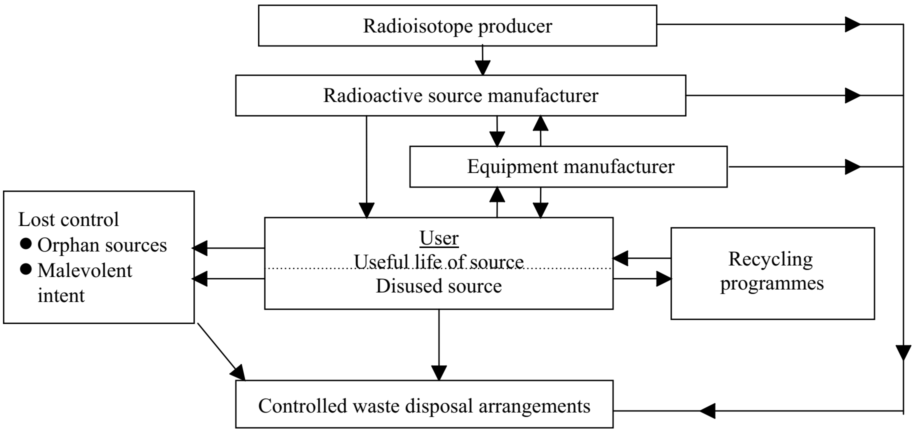

FIG. 2. Life cycle of sources.

to the safety and security of sources as those described for users in Sections 3.2 and 3.3.

3.2. Generic threats to source security

The causes for the loss of control of a source are many and varied. It may be due to a single catastrophic failure or more commonly to a combination of events. Some of the more common causes of loss of control of radioactive sources are the following.

(a) Root causes
- Lack of, or ineffective
  — regulatory bodies;
  — regulations;
  — regulatory enforcement;
- Lack of
  — national radiation protection services;
  — knowledge or training on the part of management and workers;
  — commitment by management to safety;
  — an effective radiological protection programme in the organization.

(b) Specific causes
- Lack of, or inadequate
  — prior risk assessment;
  — security during storage, transport and use;

  - radiation surveys, e.g. failure to monitor after a γ radiography exposure;
  - supervision;
  - emergency preparedness plans;
- Design or manufacturing fault;
- Inappropriate maintenance procedures;
- Human error;
- Deliberate avoidance of regulatory requirements;
- Abandonment;
- Catastrophic event, e.g. fire, explosion, flood;
- Theft;
- Malevolent act;
- Loss of corporate knowledge, due to
  - loss or transfer of key personnel;
  - bankruptcy;
  - long term storage of sources;
  - decommissioning of plant and facilities;
- Death of owner;
- Inhibitions to legal disposal, such as
  - no disposal route available;
  - export not possible;
  - high costs of disposal.

An effective regulatory infrastructure will incorporate measures to eliminate or minimize the above problems. However, it has to be recognized that it is not just a case of having an appropriate set of regulations. The regulators have to have an appropriate knowledge and skills base (in short, to be trained) and need the support of an adequate radiation protection infrastructure. By their regulatory enforcement programme, the regulators can set the tone of user compliance. Together with input from qualified experts (from the radiation protection infrastructure), this strongly influences the development of the safety culture amongst users. Safety culture is an intangible but readily recognizable characteristic that takes time to develop. The consequence is that although many countries are making significant steps forward to develop a regulatory infrastructure, the development of a safety culture will lag behind and threats to source security will remain an issue.

Even mature regulatory infrastructures cannot completely eliminate the threats. Periodically the effectiveness of the arrangements needs to be reviewed in the light of accidents and incidents that have occurred or might occur. One aspect of this might be to look at the possible threats through the life patterns of use of sources. Figure 3 provides a schematic representation of one such approach. In Section 4 examples are given of incidents and accidents that have arisen from the listed shortcomings.

4. EXAMPLES OF FAILURES IN SOURCE SECURITY

4.1. Illegal importation/purchase

In 1977 a 37 TBq ^{60}Co teletherapy unit was bought from a hospital in the USA by a hospital in Juarez, Mexico [17]. It was not imported legally and the

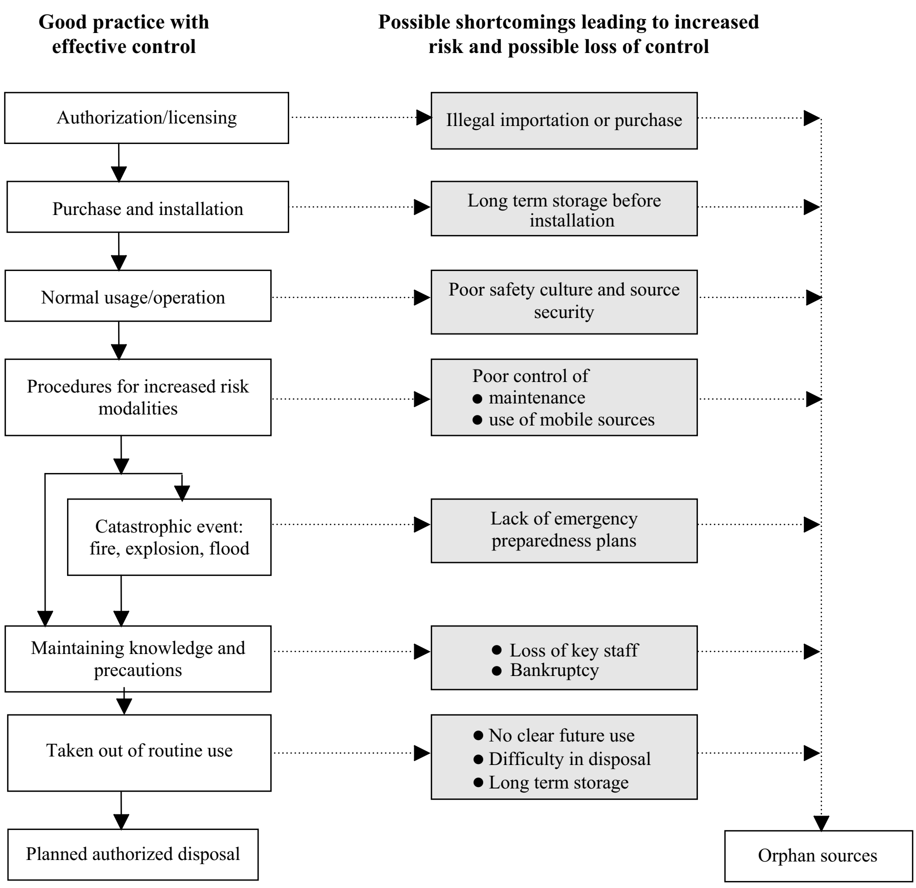

FIG. 3. Challenges to good practice.

authorities were unaware of it. The hospital did not have the resources to use it immediately and it was put into storage in a commercial facility without a clear indication of the hazards. The relevant senior staff left the hospital. In 1983 a junior member of staff who knew of its existence, but had no knowledge of the hazard, removed it to sell as scrap metal. During transport of the source it was ruptured and some small source pellets were scattered along the road. The source was smelted in a foundry and was only discovered when a lorry carrying contaminated products set off the alarms as it passed the gate at Los Alamos National Laboratory in New Mexico.

Some 75 people received doses of between 0.25 and 7.0 Gy, 814 houses with activity in the steel reinforcing bars had to be demolished, several foundries required extensive decontamination and the waste generated amounted to 16 000 m^3 of soil and 4500 t of metal.

This accident provides an example of a combination of causes: illegal importation preventing regulatory oversight, together with long term unsecure storage before use, and loss of key staff. Had regulatory oversight been possible from the start, i.e. legal importation and authorization, the other causes of the accident could have been prevented.

4.2. Normal usage

The list in Section 3.2 includes many possible causes of loss of control of radioactive sources that provide challenges to source security during the normal usage of radioactive sources. Management commitment, training and overall safety culture are key elements in ensuring appropriate safety and security measures throughout the useful life of radioactive sources. However, there are many instances of good systems being introduced at the beginning of usage, but not being maintained throughout the useful life of sources.

4.2.1. Brachytherapy sources in hospitals

There are different types of brachytherapy radioactive sources, ranging from 50–500 MBq ^{137}Cs sources, used in interstitial manual techniques, to 400 GBq ^{192}Ir sources used in remote afterloading techniques. A major radiotherapy unit could have several hundred brachytherapy sources that are continually being moved and manipulated. This provides an increased potential for failures in following procedures and for sources to be lost. There have been many reported instances of such sources leaving hospitals in refuse, or still implanted in patients or cadavers. To address this problem, countries often require hospitals to have installed radiation detectors at relevant exit points.

Even so, there are still reported instances of sources being lost. Typically this comes about from a combination of:

(a) Complacency on the part of those manipulating the sources — “familiarity breeds contempt” — leading to failure to follow procedures;
(b) Poor maintenance of detector systems, either of the equipment itself or of its positioning in what may be a changing environment;
(c) Lack of management oversight to recognize and address the problems.

4.2.2. Radioactive sources in the nuclear industry

Within a nuclear fuel cycle facility a high profile is given to the security of nuclear material and fission products. The same may not always be the case for radioactive sources. Following a minor incident at a nuclear facility in the United Kingdom involving the security of a conventional radioactive source, the company carried out a review of the security arrangements for such sources. They found that for the over 2000 sources they had on the site, these arrangements needed improving, particularly in respect of keeping inventories up to date. Although all the sources were accounted for, many were in different locations than the records showed, having been moved from one location to another for operational reasons. In locating all the sources they realized that a visual image of each source or device was important. As a result they now have a policy of having an electronic image of all their sources to supplement the inventory record and to facilitate finding a source were it to be lost.

4.3. Increased risk modalities

Some types of use provide increased challenges to source security. Whilst maintenance of equipment is often an essential element of a radiation safety programme, it can also provide greater scope than normal usage for mishaps. This is because maintenance work often requires the overriding of installed safety systems or working in an environment where the operators may not be fully familiar with the local arrangements or hazards. If the work is not properly planned by well trained staff, the net effect has in some cases been that the radioactive source has been left in an unsecure state.

Another increased risk modality is that of mobile sources. Common examples are sources used for industrial radiography (Section 4.4) and those used in oil exploration, the mining industry and construction work for the determination of density, porosity and moisture, or the hydrocarbon content of geological structures or building materials. The sources in their containers are transported from site to site in cars or vans and may be left overnight in the vehicle or temporary storage facilities that may not be secure. There have been instances of the vehicles (with the devices in them) being stolen. The thieves may or may not recognize the significance of the contents, and often the devices with the radioactive sources in them are abandoned in the public domain.

4.4. Industrial radiography accidents

Industrial radiography is in widespread use, and has a high hazard potential. The construction of petrochemical installations, for example, will involve the use of portable radiographic sources of up to 5 TBq for testing welds in pipes and tanks. Some years ago ^{137}Cs sources were used and some of these may still exist. Currently, sources will most often be ^{192}Ir or ^{60}Co, but ^{169}Yb, ^{170}Tm or ^{75}Se may also be used. The housings for these portable sources contain several tens of kilograms of shielding material, such as depleted uranium, lead or tungsten, which may be perceived as being potentially valuable. Also relevant is the fact that the portable nature of this equipment allows it to be used almost anywhere. Often its use is in remote locations or under extreme working conditions. Couple this with the often limited or non-existent supervision and there is a real potential for entire containers with their sources to be lost or stolen. They can end up in the metals recycling industry or lay dormant in random locations in the public domain.

However, perhaps the most significant threat comes from loss of the source on its own. Most remote exposure radiography source containers have the same general design. The source capsule is physically attached to a short, flexible unit often known as a ‘source pigtail’. This is designed to be coupled, often with a spring assisted ball and socket joint, to a flexible drive cable. When not in use, the source is located in the centre of the source container. In use, a guide tube is attached to the front of the container and the source is pushed down it to the required position by winding out the drive cable. Poor maintenance, incorrect coupling, obstructions or kinks in the guide tube can all lead to extreme pressures being placed on the various linkages and eventually to the source becoming decoupled from the drive cable. This poses an immediate threat to the radiographer, who must monitor after every exposure to ensure that the source has fully returned to the safe shielded position. Failure to do so has led to serious exposure of the radiographer and to the source dropping out of the equipment unnoticed. To members of the public who find such radiography sources, they look like intriguing items and can easily be picked up and carried back to the family home, often with lethal effects, as illustrated below.

4.4.1. Morocco, 1984

In the serious accident in Morocco in 1984, eight members of the public died from overexposure to radiation from a radiography source. A 1.1 TBq ^{192}Ir source became disconnected from its drive cable and was not properly returned to its shielded container. Later the guide tube was disconnected from the exposure device and the source eventually dropped to the ground, where a passer-by picked up the tiny metal cylinder and took it home. The source was lost from March to June, and a total of eight persons (the passer-by, members of his family and some relatives) died; the clinical diagnosis was lung haemorrhages. It was initially assumed that the deaths were the result of poisoning. Only after the last family member had died was it suspected that the deaths might have been caused by radiation. The source was recovered in June 1984.

4.4.2. Yanango, Peru, 1999

In the accident in Yanango, Peru [10], γ radiography using a 1.37 TBq ^{192}Ir source in a remote exposure container was being carried out at the Yanango hydroelectric power plant. At some stage the source pigtail became detached from its drive cable. A welder picked up the source, placed it in his pocket and took it home. The loss of the source was noticed the same day and the source was recovered within 24 hours. However, the dose received in this period was such that despite heroic medical treatment the welder lost one leg and had other major radiation burns. His wife and children were also exposed, but to a lesser extent.

4.4.3. Cairo, Egypt, 2000

The incident in Cairo, Egypt, in 2000 was very similar to the two incidents described above. A farmer picked up a 3 TBq ^{192}Ir source, and thinking it valuable, took it home. On 6 May 2000 the farmer and his nine year old son went to their local doctor complaining of skin burns. The doctor prescribed medication for a viral or bacterial infection. The son died on 5 June and the farmer on 16 June. On 26 June a blood test was done on other family members who were showing similar symptoms. The blood test showed severe depression of the white blood cell count, and radiation exposure was suspected. The source was located and recovered. Other family members were hospitalized. Four men were charged with gross negligence, manslaughter and unintentional injury because they had failed to notify the authorities that the source, used to inspect natural gas pipeline welds, was not recovered after the job.

4.5. Challenging events

During the life of some sources there may be some occasions when the safety and security measures are challenged through abnormal situations, e.g. fires, floods, explosions and transport accidents. The first requirement is recognition that an event may have a source security implication. This should then lead to the triggering of appropriate emergency preparedness plans. The greater the delay in implementing the emergency preparedness plan, the longer there will be uncontrolled exposure and the greater will be the area over which there may need to be searches for lost sources.

4.5.1. San Salvador, 1989

The accident in San Salvador in 1989 [6] occurred in an industrial irradiation facility containing 0.66 PBq of ^{60}Co in the form of a source rack of two modules each containing a number of source pencils. At the time of the accident there was no relevant regulatory or radiation safety infrastructure, and the country had been in a civil war for ten years. The net effect was a degradation of the safety systems and the operators' understanding of radiation hazards. In this accident, three people gained entry to an irradiation chamber to free the source rack, whose movement to the safety of the water pit had been impeded by distorted product boxes. One person died and another had a leg amputated.

The occurrence was not recognized for two weeks, and during this time damage to the source rack from the accident caused the source pencils to drop out. Most fell into the water pit, but one fell onto the floor of the irradiation chamber. It is pure chance that none fell into one of the product boxes, which could have led to their transfer out of the facility. The installed monitor on the product exit, designed to detect such an event, had long since failed. Some six months after the accident an IAEA team visited the plant to carry out an accident investigation. By that time the source pencil from the irradiation chamber had been recovered and shielded by the supplier, but the other source pencils were still at the bottom of the water pit awaiting recovery. Importantly, no one had confirmed that the total inventory of source pencils had been accounted for and that none had left the plant. At the insistence of the IAEA team an underwater photograph was taken to confirm that all the source pencils were accounted for.

4.5.2. Tammiku, Estonia, 1994

In the accident in Tammiku in 1994 [2], a cylindrical radioactive source in a metal frame was found in a consignment of scrap metal imported to Tallin, Estonia. The source, with an activity of up to 7.4 TBq ^{137}Cs, was thought to be a part, just a small part, of a seed irradiator (leaving open the question of where the rest of it was). In this case the first part of the emergency preparedness plans worked and the source was successfully recovered and taken to the national waste disposal facility. Unfortunately this was just an underground concrete bunker with poor security. Three brothers broke into the facility and stole the source for resale as scrap metal. As a result one brother died from radiation exposure and the other two brothers, plus two other family members, suffered significant deterministic effects.

The original finding of the source in scrap metal imports had raised queries about other possible orphan sources being in Estonia, and a Government commission to assess the situation was set up. During its work it found a 1.6 TBq ^{137}Cs source in a container that had been abandoned close to a main road in the countryside.

5. MAINTAINING KNOWLEDGE AND PRECAUTIONS

Over the useful life of a radioactive source, which may be decades, there can be challenges to keeping the corporate knowledge of the source security requirements or even knowledge of the existence of the sources. For example:

(a) The knowledge of the source security arrangements may be vested in one or two key staff, without it being properly covered in safety documentation or covered by management oversight. When those key staff leave, the source security arrangements will degrade.

(b) A sudden change in ownership can remove all corporate knowledge of the need for source security arrangements. The accident described in Section 5.1 provides an example of the change of ownership of a facility between nations, where knowledge was not passed on.

(c) Bankruptcy can also remove corporate knowledge. This can happen very suddenly, in some cases with everybody walking away from the problem and leaving a derelict facility. Although the accident in Goiânia described in Section 5.2 is not a case of bankruptcy, it has the same characteristics, e.g. abandonment of responsibility.

5.1. Lilo, Georgia

In 1992, with the breakup of the Soviet Union, the Soviet Army abandoned its former facilities in Georgia. One of these was a training camp in Lilo, which was taken over by the Georgian Army. In October 1997, 11 soldiers developed radiation induced skin lesions. A radiation monitoring search of the facility revealed 12 abandoned ^{137}Cs sources, ranging from a few MBq to 164 GBq [3]. These had been used by the previous occupants in civil defence training, with the sources being hidden about the site and trainees having to find them. Many sources were still where they had been hidden. In addition, one ^{60}Co source and 200 small ^{226}Ra sources used on gun sights were also found on the site.

5.2. Goiânia, Brazil

In 1987 in Goiânia, Brazil [1], a private medical partnership specializing in radiotherapy broke up acrimoniously. No one took responsibility for a 50 TBq ^{137}Cs teletherapy unit that was left abandoned in the partially demolished building of the former clinic. After two years some local people dismantled the source and its housing and removed it for its value as scrap metal. In the process the source was ruptured. The radioactive material was in the form of compacted caesium chloride, which is highly soluble and readily dispersable. For over two weeks the radioactivity was spread over parts of the city by contact contamination and resuspension. Contaminated items (and people) went to other parts of the country.

The recognition of the existence of the problem was triggered by an increasing number of health effects. Overall some 249 people were externally contaminated, 129 internally; 21 people received in excess of 1 Gy and were hospitalized. Of these 21, 10 needed specialized medical treatment, 4 of whom died. The decontamination and cleanup of the environment took six months of intensive effort and produced 3500 t of active waste.

In passing, it is worth noting that although not an example of terrorism, the Goiânia accident provides a good example of the possible consequences of the use by terrorists of an improvised radiological dispersal device.

6. DISUSED SOURCES

There are a number of similarities between the issues identified in the previous section and the problem of disused or spent sources. Both involve the loss of corporate knowledge or awareness of source security issues, but this section focuses on the end of life issues of radioactive sources. Perhaps the main characteristic here is that at some stage there has been a recognition that the sources, or the equipment they are in, have come to the end of their useful life or there is no clear future use for them. This can manifest itself in many ways.

(a) The sources can simply be removed to storage on-site and through lack of management are not disposed of but simply left. Over time the safety and security arrangements degrade until eventually control is lost and the source may end up in the public domain, especially in the metals recycling industry. The accidents described in Sections 6.1 and 6.2 provide significant examples of this.
(b) A variation on the above theme is that the sources are left in situ, e.g. in level gauges on a disused part of a petrochemical facility. Eventually when that part of the plant is demolished, all the metal, including the sources, ends up in the metals recycling industry and the source may be smelted. There are many such recorded events, which can be very costly — in the range US $1 million to 100 million [12].
(c) In many cases the management takes a conscious decision not to dispose of the source, simply because the costs of disposal are very high. Whilst security arrangements may be maintained to a degree, the effect of this practice is to increase the potential for security to fail over time. It has been estimated that in the USA 500 000 of the two million sources may no longer be needed and thus could be susceptible to being orphaned [18] or a target for malevolent intent. In the European Union some 30 000 sources are in a similar position [19].

6.1. Istanbul, Turkey

In 1993 a licensed operator loaded three spent radiotherapy sources into transport packages for their return to the original supplier in the USA [4]. However, the packages were not sent and were stored in Ankara until 1998. Two were then transported to Istanbul and stored in a general purpose warehouse. After some time the warehouse became full and the packages were moved to empty adjoining premises. After nine months these premises were transferred to new ownership, and the new owners, not knowing the nature of the packages, sold them as scrap metal. The family of scrap merchants broke open the source container and unwittingly exposed themselves to the unshielded 3.3 TBq ^{60}Co source. Ten people received doses of between 1.0 and 3.1 Gy and showed signs of acute radiation syndrome. Fortunately no one died.

The second source, 23.5 TBq ^{60}Co, remains unaccounted for, despite an extensive search and monitoring programme.

6.2. Samut Prakarn, Thailand

One company in Bangkok possessed several teletherapy devices without authorization from the Thailand Office of Atomic Energy for Peace [5]. In the latter part of 1999, the company relocated the teletherapy heads from a warehouse it had leased to an unsecured storage location. In late January 2000, several individuals obtained access to this location and partially disassembled a teletherapy head containing 15.7 TBq of ^{60}Co. They took the unit to the residence of one of the individuals, where four people attempted to disassemble it further. Although the head displayed a radiation trefoil and warning label, the individuals did not recognize the symbol or understand the language. On 1 February 2000, two of the individuals took the partially disassembled device to a junkyard in Samut Prakarn. While a worker at the junkyard was disassembling the device using an oxyacetylene torch, the source fell out of its housing unobserved.

By the middle of February 2000, several of the individuals involved began to feel ill and sought assistance. Physicians recognized the signs and symptoms and alerted the authorities. After some searching through the scrap metal pile, the source was found and recovered. Altogether, ten people received high doses from the source. Three of those people, all workers at the junkyard, died within two months of the accident as a consequence of their exposure.

7. CONCLUSIONS

It was clear even before the terrorist attacks of 11 September 2001 that there was a significant orphan source issue arising from poor safety and security of radioactive materials around the world. The IAEA's Action Plan to address this has made progress, but it is clear that there is a long way to go, particularly in improving the development of regulatory control in many countries.

Even where there are mature regulatory systems, enforcement of source security has until recently been focused on preventing unintended access to sources. There is therefore a need to revisit the benchmarks for practical source security to take into account malevolent intent. In doing this we must not lose sight of the benefits to be derived from the use of radioactive sources. Good judgement will be required to balance the value of ease of use of radioactive sources against the threat from malevolent intent.

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DISCUSSION

H.D.K. CODÉE (Netherlands): Do you have information about threat assessments relating to biological or chemical substances that could be stolen and used in dirty bombs?

J.R. CROFT (United Kingdom): No. However, in the United Kingdom there is a programme for assessing the threats from all substances that terrorists might use and devising appropriate strategies.

D. SUBASIC (Croatia): Further to what you said about Croatia, I would mention that some 200 sources were recovered in an operation for which I was the project leader.

From Croatia's experience during the war period from July 1991 to September 1995 it is clear that sources can easily become orphaned as a result of military activities. We should bear in mind, however, that sources can become orphaned also as a result of natural catastrophes such as earthquakes and floods.

Also, our experience during that period showed that a well organized system of registration and licensing helps to keep down the number of sources becoming orphaned in wartime.

IDENTIFICATION OF HIGH PRIORITY RADIOACTIVE SOURCES BASED ON RISK

C.J. PAPERIELLO
United States Nuclear Regulatory Commission,
Washington, D.C.,
United States of America
E-mail: cjp1@nrc.gov

Abstract

The paper addresses the methodology used to identify those radioactive sources of greatest concern with respect to their potential for malevolent use. It considers both the IAEA categorization process as defined in IAEA-TECDOC-1344 and the approach taken by the US Department of Energy and the US Nuclear Regulatory Commission Interagency Working Group.

1. INTRODUCTION

Categorization of radioactive sources is fundamental to the establishment of effective safety and security requirements that are commensurate with the risk posed by the sources. Moreover, proper categorization will aid clear communication for emergency notification and response and will ensure that controls on imports and exports will not unnecessarily impact domestic and international commerce in these sources

This paper addresses the methodology used to identify those sources of greatest concern with respect to their potential for malevolent use. It considers both the IAEA categorization process as defined in IAEA-TECDOC-1344[1] as well as the approach taken by the US Department of Energy (DOE) and the US Nuclear Regulatory Commission (NRC) Interagency Working Group. The draft Working Group report is currently under review at the two agencies.

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2. BACKGROUND

In his opening remarks, US Secretary of Energy Abraham spoke about the need to take action to better secure high risk radioactive sources. He outlined a series of actions which the USA intends to take to better account for these sources, to track their use, disposition, import and export, and to enhance their physical protection. The revised Code of Conduct on the Safety and Security of Radioactive Sources envisions similar actions on an international scale.

But what constitutes a high risk radioactive source? This can vary depending on the approach and the assumptions used, but it is important to have a harmonized categorization scheme so that it can be applied universally among Member States. Thus our task is to share information on the various approaches to define a path forward so that we can promptly reach consensus on this matter.

Before outlining the approaches taken in the IAEA TECDOC and the DOE/NRC Working Group, I would like to briefly discuss the basic considerations for the categorization of sources.

3. DISCUSSION

To identify those sources that pose the greatest risks, consideration must be given to a number of factors. At the most fundamental, potential health effects — both deterministic and long term — are the starting point for categorization. Deterministic or acute effects are characterized by a threshold below which the effect does not occur. The rate at which the dose is received is an important factor for deterministic effects. Projections of long term or stochastic health effects assume that the effect is linear with dose and is independent of dose rate. That is, long term effects are a probabilistic risk much like the risk of lung cancer from smoking. Not everyone who is exposed will get cancer. However, the greater the exposure, the greater the probability will be of getting cancer.

Another key factor is how the dose is received — internal versus external dose. The internal dose from radionuclides with equivalent activities can vary by a factor of as much as 100 000. In some cases, inhalation as compared with oral ingestion makes a big difference in the dose received. The same comparison applies to external dose. For example, tritium and plutonium result in little or no external dose while ^{60}Co and ^{137}Cs result in the greatest dose per unit activity.

The exposure mode is also a consideration. All exposure pathways must be considered when evaluating radioactive sources to determine which represent the greatest risk and what the threshold should be for prioritization. There are many variables to consider. For example, inhalation versus ingestion, and ground shine versus direct contact. However, there are tools to help. A number of computer codes have been developed to evaluate doses from accidental releases of radioactive material. These codes and additional codes based on their concepts provide a basis for analysis.

Other factors must be considered. First, material must become airborne to be inhaled and thus it must be in the form of sufficiently small solid or liquid particles or gas in order to enter the respiratory system. Second, the material must have an appropriate half-life. A very long half-life results in a very low specific activity such that very little radioactivity can be incorporated into a radiological dispersal device (RDD) of reasonable mass. Thus some very long lived radioactive materials, e.g. uranium and thorium, can be eliminated from consideration. On the other hand, most common diagnostic medical isotopes have half-lives shorter than several days, and thus also can be eliminated from consideration. Third, sufficient material must be available. A number of widely used β emitters, such as ^{14}C, ^{35}S, tritium, ^{32}P and ^{63}Ni, are almost never available in sufficient quantities at one location to be of use in an RDD. Finally, the form of the material is important. Solid metals are much harder to disperse than encapsulated powders.

Consideration of the dose related factors noted above has led the NRC to conclude that only a small number of radionuclides are of concern for use in an RDD, primarily ^{60}Co, ^{90}Sr, ^{137}Cs, ^{192}Ir, ^{238}Pu, ^{239}Pu and ^{241}Am. This conclusion is similar to the results of the IAEA categorization effort.

With that as the basis for the identification of radionuclides of concern, the DOE/NRC Working Group proceeded to define activity levels for these radionuclides above which a source could be considered high risk and where near term additional security measures, appropriate to various uses of the source, may be warranted. Examined as a part of this effort was the methodology used in previous efforts to categorize the safety of radioactive sources, including a DOE categorization scheme and IAEA-TECDOC-1191, Categorization of Radiation Sources[2]. Both schemes were largely based on a direct exposure analysis. How many sieverts will a person receive at one metre from the source over some period of time? This analysis is appropriate for the subset of RDDs which do not involve dispersal of the radioactive material by

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Categorization of Radiation Sources, IAEA-TECDOC-1191, Vienna (2000).

an explosive device. These devices, like the one placed in a Moscow park by Chechen rebels, in some ways are more insidious than an explosive device because there is no explosive signature to reveal the weapon.

4. IAEA-TECDOC-1191/1344

In IAEA-TECDOC-1191 and its successor, IAEA-TECDOC-1344, the starting point is the definition in international practice of a dangerous source. A dangerous source is defined as: “A source that could, if not under control, give rise to exposure sufficient to cause severe deterministic effects.” Dangerous sources are defined by radionuclide specific activity levels for the purposes of emergency response, which are termed D values. The D values consider all pathways of exposure. The quantity of specific radionuclides used in each practice (defined as the A value) is divided by the corresponding radionuclide specific D value, giving an A/D ratio that is used to develop categories. The ranges of A/D for each category were selected on the basis of expert judgement.

Although the approaches taken in IAEA-TECDOC-1344 and the DOE/NRC Working Group resulted in the identification of high risk and low risk radioactive sources that are similar, further technical review of IAEA-TECDOC-1344 is warranted. For example, I believe it may be appropriate to include consideration of health effects from malevolent events that result in dispersal of contamination across large areas above the levels requiring an intervention. This is consistent with the objectives in the Code of Conduct to prevent harm to individuals, society or the environment.

5. DOE/NRC WORKING GROUP

This leads me to the results of the DOE/NRC Working Group. It must be borne in mind that the following information contains preliminary results and that the analysis is still in the management review process. As noted previously, the Working Group considered past studies in the USA. The DOE had for the purposes of classifying its own material established risk categories based on dose impact. The DOE Category 3 source levels are based on the amount of material, in suitable form, that is capable of delivering a dose of 100 mSv, on the basis of the contribution from direct exposure and inhalation, to a person located 30 m from the point of dispersal for a 24 h period of exposure and a longer time period of ingestion. This dose level would not produce short term deterministic effects in any exposed individual, although it would theoretically increase the long term risk of cancer. Because the DOE analysis tables already existed, sources possessed by the DOE and sources licensed by the NRC for possession were screened against this criterion.

To further specify sources of concern, we used two additional steps. First, we considered direct exposure from γ emitters, isotopes such as ^{60}Co and ^{192}Ir. A dose rate threshold of 0.25 Sv/h at 1 m was used on the basis of a scenario where a person was unknowingly exposed to a concealed source for 8 h at 1 m, and received a dose of 2 Sv. This was the limiting criterion for determining action levels for γ emitting radionuclides of concern.

As a second step, further analysis was undertaken to identify sources bearing a threat of long term contamination from dispersal. In evaluating the criterion for dispersal, we considered that RDDs are poor weapons which will kill either no, or very few, people outside the immediate explosion. However, it was recognized that RDDs disrupt society by creating public panic based on fear of radiation, and they also create a zone where significant cleanup efforts must be undertaken at potentially great cost. The US Environmental Protection Agency has established an intermediate protective action level of 20 mSv/a if a radiological event should occur. Thus we chose that level as a measure of disruption for our analysis. We then chose 0.5 km^2 as the area which could be contaminated up to the 20 mSv/a level by an explosive driven RDD in order to determine a limit on the size of the source. We undertook the analysis using an all-pathways model. This was the limiting criterion for determining action levels for β and α emitting radionuclides of concern.

The initial action thresholds identified by the Working Group are the basis for applying protective measures in the near term, as appropriate. Although based on an NRC methodology, they are analogous to action levels for similar quantities of radioactive materials of concern for use in an RDD evaluated within the DOE's Design Basis Threat Policy. The action thresholds identified are about 1–2 TBq for the most commonly used β–γ emitters, about one third of a terabecquerel for the most commonly used α emitters and about 4 TBq for ^{90}Sr. These action levels can serve as a definition of a high risk radioactive source. In the USA these high risk radioactive sources have always required specific licensing and they are periodically inspected by trained government radiation protection specialists. However, on the basis of this analysis, the NRC will be taking additional security measures.

An important conclusion from this analysis is that the vast majority of radioactive sources cannot generate contamination at this level or anything close to it, and only a small fraction pose a substantial radiological risk. For most radioactive sources, the current US regulatory system as well as the security systems of the DOE are sufficient to ensure safety and will probably provide adequate security as well.

6. INTEGRATION OF RESULTS UNDER THE CODE OF CONDUCT

As I said earlier, the definition of high risk radioactive sources is central to our efforts to prevent the malevolent use of sources. Moreover, establishment of a fundamental understanding of and consensus on the science and underlying assumptions is key to the success of any categorization scheme. Under the draft Code of Conduct, high risk radioactive sources should have cradle to grave regulatory control, controls for export and import, and tagging, as well as additional security measures. This application suggests the importance of a simple and universal scheme. An export and import control system based on a single activity level for the radionuclide, regardless of the intended use of the source, would accomplish this. If the categorization scheme becomes too complex, the administrative costs of implementing the export and import controls become overwhelming. The same is true for national regulation of high risk sources.

7. THE PATH FORWARD

What is our path forward? Although both IAEA-TECDOC-1344 and the DOE/NRC Working Group specify activity levels that define high risk radioactive sources, neither approach is perfect. Different choices are clearly possible on such matters as the measure of disruption for RDDs involving α and β emitting radionuclides of concern. Moreover, there is significant uncertainty in the tool we have used to model dispersal. Nonetheless, we plan to share the DOE/NRC Working Group methodology with our international partners in order to reach consensus as rapidly as possible on an appropriate categorization scheme.

I believe that with a concentrated effort we can reach consensus on the definition of high risk radioactive isotopes in the near term. Above all, I believe that it is essential that the categorization of high risk sources be simple and implementable within national regulatory systems. Categorization is the cornerstone on which the entire international system of control of high risk sources will be based. We need to get it right.

DISCUSSION

V. KOSENKO (Ukraine): When defining the activity levels for α emitters, did you take chemical toxicity into account?

C. PAPERIELLO (USA): No, chemical toxicity was not taken into account in our modelling. However, in the USA, protective actions for uranium hexafluoride are based on chemical toxicity.

P.T. BURDUKOV (Russian Federation): Has the DOE/NRC Working Group you referred to considered the risk of higher radiation doses in Iraq due to the combustion of large quantities of oil if the USA takes action against that country?

C. PAPERIELLO (USA): In our modelling, we used a variety of materials to convert the various isotopes into different forms. We considered dispersal based on the physical and chemical form of the radioisotope and the type of explosive available. The numbers that I showed you represent some fairly conservative bounding values for the various things that you could do with the sources. As you are well aware, typically cobalt and iridium are in the form of solid metal. In some cases it is completely solid and in other cases there are either pellets, in the case of some cobalt sources, or there is actually flake material in the case of iridium. I am aware that in some sources there are iridium wires. So the codes allowed us to vary the chemical and physical form of the material because it would then cause a different percentage of the material to become airborne. In my presentation I said that the material must be a particulate that is small enough, firstly, to become airborne and secondly, to be respirable. Therefore we could take into account the respirable form of the material, and obviously caesium tends to be used in a salt, in which case it is very dispersible and soluble, and in some cases, particularly in newer or in small sources, it is absorbed onto a zeolite and, at least in the USA, it is fired and, in my experience, it will not leach out of the zeolite and the zeolite is not respirable, but it can spread and it will be an external risk.

R.V. ARUTYUNYAN (Russian Federation): Regarding the categorization of radioactive sources, if we use dose criteria, the proposed limits greatly depend on our understanding of possible damage, perhaps 100 mSv as a limit. This would be the point at which the radiation implications are not factual but purely theoretical in terms of a non-threshold approach. But in terms of accidents these zones are not determined so much by dose, but the oblique damage that has been mentioned here. So you have criteria that go from 1 mSv, which in some countries is the dose limit from which you have to take steps — under normal conditions, of course. But the reaction of the population and society is such that measures have to be taken on territories where one is already talking about millisieverts, and on this depends the scale of damage and the activity which one takes into account as causing serious problems.

Another point is that, when we categorize the source, we have to think in terms of having one source lower than the limit, and it is better to talk in terms of a hundred small sources than one very large one.

C. PAPERIELLO (USA): I agree. When you model or when you devise a categorization scheme, you are going to have to base it on something other than an arbitrary number. It is going to be based on a decision to ignore certain things — in other words, we will look at direct dose and ignore contaminated land or we will look at contaminated land too, or we ignore the direct dose and we only look at contamination — and then you need a criterion. The criterion we chose was one that was already in use in the USA for nuclear power plant accidents with non-malevolent causes. It is in the range of doses that under the ICRP 82 criteria/criterion would suggest an intervention that falls within that range. Obviously, you can set the contamination levels so ridiculously low that just dumping fertilizer on the ground would constitute a radiological dispersal device. I do not think the number we chose is too far out of line with what we understand as the international intervention levels, which are somewhere between 10 and 100 mSv/a. After all, you are talking about a lifetime of exposure on that land.

T.C. KOTZÉ (South Africa): What are the criteria on the basis of which a decision whether or not to evacuate a city, or part of a city, would be taken following the explosion of a dirty bomb — the increase in additional deaths from cancer?

C. PAPERIELLO (USA): In the USA there are no criteria specific to dirty bombs. We would probably use current Protective Action Guides (PAGs) developed for nuclear reactor accidents. The intermediate PAG for a one year exposure is 20 mSv. The long term PAG is 5 mSv/a.

H.D.K. CODÉE (Netherlands): I conclude from your presentation that only very large radioactive sources could do serious radiological harm. Most such sources are under control. Can you give an estimate of the number of sources that pose a real danger?

C. PAPERIELLO (USA): Very few of the radioactive sources in use are suitable for RDDs — in the USA, one in 1000–10 000, and that does not include the millions of exempt sources in devices like smoke detectors and the millions of short lived medical diagnostic sources used every year. Moreover, many radioisotopes (for example ^{14}C and ^{35}S) are never used as sealed sources.

K. GRYSHCHENKO (Ukraine): In my view, the public reaction to a dirty bomb will depend less on how powerful the radioactive source was than on how the incident is treated in the media.

C. PAPERIELLO (USA): I agree. In the USA, the NRC and other federal agencies are taking this matter very seriously and working out plans for communicating with the public before and after a dirty bomb incident. I think the public must be given clear, correct information; any attempt to mislead people will only create mistrust.

SEARCH FOR ORPHAN GAMMA RADIATION SOURCES: EXPERIENCES FROM THE BARENTS RESCUE 2001 EXERCISE

R.R. FINCK
Swedish Radiation Protection Institute,
Stockholm

T. ULVSAND
Division of NBC Defence,
Swedish Defence Research Agency,
Umeå
E-mail: thomas.ulvsand@foi.se

Sweden

Abstract

The paper describes the Gamma Search Cell exercise that was performed during the exercise Barents Rescue 2001. Teams from Austria, Denmark, Estonia, Finland, Germany, Iceland, Latvia, Lithuania, Norway, Poland, the Russian Federation and Sweden participated. During the three day exercise, the teams had the opportunity to search for 31 gamma radiation sources of seven different nuclides under realistic conditions and to report their findings to the specially established Radiological Emergency Assessment Centre. The search was performed with helicopters and cars on the military exercise ground outside Boden in the northern part of Sweden. The sources were hidden in many different ways, for example in tracked vehicle carts off-road or in concrete fire trenches. One strong source was hidden in a drainage drum under a road, one was partly shielded by a large stone block and several were hidden in houses. On average about half of the sources were located by the airborne and car-borne teams. Some sources were not found at all. The paper gives information about the design of the exercise, the search results and the conclusions drawn. The results show the possibilities and difficulties of this type of mission. The paper concludes with some ideas about future exercises.

1. BACKGROUND

In 1999 the Swedish Government decided to start arrangements for an international exercise to take place in northern Sweden during 2001 on the theme of a nuclear emergency. The Swedish Rescue Services Agency was commissioned to plan and realize the exercise, named Barents Rescue 2001.

Several Swedish authorities were also ordered to participate in the arrangements for the exercise, including the Swedish Armed Forces, who were to provide practical support. The Barents Rescue exercise was designed in two main parts: an international alarm exercise (ALEX) and a command and field exercise (LIVEX). European countries were invited to participate directly or as observers. LIVEX was designed to contain an exercise on the theme of orphan gamma radiation sources, which were to be searched for and identified over large areas using airborne and car-borne measuring equipment. The aim was to make the search exercise as realistic as possible with real gamma radiation sources. This part of LIVEX was named the Gamma Search Cell exercise. Teams from Austria, Denmark, Estonia, Finland, Germany, Iceland, Latvia, Lithuania, Norway, Poland, the Russian Federation and Sweden were invited and participated in the Gamma Search Cell exercise. The exercise took place on the large military exercise grounds at Boden, in the northern part of Sweden, during three days, 17–19 September 2001. Altogether nine airborne gamma spectrometry teams, three airborne search teams and 19 car-borne search teams performed search measurements. The planning, methods and results of the Gamma Search Cell exercise are briefly described here. A more detailed account with results from each team is available from the NKS-54 Report [1].

1.1. Aim of Barents Rescue 2001

The aim of Barents Rescue LIVEX 2001 was to improve the capability to lead rescue services in response to a large accident such as a nuclear accident or a radiological emergency and for international co-operation between civilian authorities with the support of national and international military resources. The aim was also to improve the capability to assess a radiological emergency on the basis of actual measurements in the field.

Planning of the Barents Rescue exercise was carried out through co-operation between the countries invited. Three international planning conferences were held during a period of about one and a half years before the exercise. A number of workshops were also held for detailed planning of different parts of the exercise. In the planning process it was decided that Barents Rescue 2001 should contain different sub-exercises with different themes and timescales in order to illustrate different aspects of nuclear and radiological emergencies.

The early phase of a nuclear emergency was tested in the international alarm exercise ALEX in March 2001. It was a surprise alarm exercise involving a fictitious nuclear power plant in northern Sweden. Participating countries and authorities took part in the ALEX exercise from their own emergency response centres.

1.2. Choice of a scenario with orphan sources

The aim of the final part of the Barents Rescue exercise, LIVEX, was a joint international field exercise with monitoring and rescue teams in place in Sweden. During the main planning conference it was decided that a challenging exercise would be a large scale search for orphan gamma radiation sources, simulating a radiological emergency with lost radioactive sources.

Accidents with lost sources have occurred a number of times, for example the Cosmos-954 re-entry over Canada in 1978 [2] and the Goiânia accident in Brazil in 1987 [3]. Recently, two high activity ^{90}Sr sources were found by members of the public in the Republic of Georgia. The men who found the sources were unaware of the danger and suffered serious injuries from overexposure [4]. Events with lost radioactive sources could necessitate international assistance with airborne and car-borne measurements, medical treatment of irradiated people, evacuation and decontamination of highly radioactive areas, etc.

Large scale exercises on the theme of lost radiation sources have been rare. In the Nordic counties only one international exercise has been carried out on this theme. It was the RESUME-95 exercise in Finland in 1995 [5], in which one task was to locate a number of gamma emitting point sources from the air over a search area of about 10 km^2. Measurements on foot were not allowed, but the exercise still provided valuable findings. Experience from the RESUME-95 exercise was therefore implemented in the design of the larger Gamma Search Cell exercise, which used five search areas and a combination of airborne and car-borne measurements and measurements on foot.

Lost sources were also the theme of the Command Exercise and the Field Exercise parts of LIVEX. According to the LIVEX scenario an unknown number of radioactive sources were suspected to have been illegally buried in the large bogs and forests of northern Sweden in the 1950s and 1960s. For some reason, perhaps owing to road construction, at least one of the buried sources had reappeared and caused radiation injury. Parts of this source, and possibly other sources, could have been spread over thousands of square kilometres. The task for the search teams of the Gamma Search Cell exercise was to locate as many sources as possible within the areas defined by the exercise management.

2. DESIGN OF THE GAMMA SEARCH CELL EXERCISE

The search for orphan gamma radiation sources over large areas was designed to be a practical experiment where different teams, measuring equipment, assessment methods and tactics could be compared. Rapid positioning and identification of the sources found, including the reporting of source data to a Radiological Emergency Assessment Centre, was encouraged to obtain a near realistic emergency situation.

2.1. Search areas

About ten helicopter teams and 15 car-borne teams had preannounced their participation in the Gamma Search Cell exercise. In a real emergency situation each team would have been assigned to a specific search area in order to cover as large a total area as possible. In that case most teams would probably not have found any sources. Such a situation would not be appropriate for an exercise where each team should have the possibility to test their search methods on a number of different sources and geometries. Therefore a compromise between realism and usefulness had to be made. The exercise was set to continue for three days and each team was to have the possibility to locate a number of sources each day, as far as possible without interference from other teams. This would require at least as many sources as there were teams and enough space for all search areas. For car-borne teams the road lengths had to be about a hundred kilometres each day. For airborne teams at least two hours of flight time had to be planned for each day. The I19 Regiment of the Swedish Armed Forces in Boden was able to offer suitable areas satisfying these demands. The regiment arranged for the use of hundreds of square kilometres of its exercise grounds (firing ranges) north-west and south-west of Boden.

For car-borne teams, five search areas were defined (C1–C4, C7). These were to be covered during the three days of the exercise, with 1–8 sources being placed in each area. This meant that 3–4 car-borne teams had to use the same area at the same time. To allow all car-borne teams to have the same prerequisites within each area, information on identified source locations was kept secret between teams until the end of the exercise.

For airborne teams five search areas of 2 km × 5 km (A1–A5) were defined. The areas for car-borne search overlapped the areas for airborne search, except for area A5, where the strongest radioactive sources were placed. The area A5 was not allowed to be entered by car-borne teams.

In a real situation the findings from the airborne search would be followed up on the ground with handheld equipment. The exercise management decided that this practice should be allowed and encouraged in the exercise. Therefore all car-borne teams were granted access to results from at least one airborne team. The information exchange between airborne and car-borne teams was assigned country by country. Countries without airborne teams were allowed access to Swedish airborne results. The time and area slots of airborne and car-borne teams were distributed such that car-borne teams generally could access areas that had been covered by airborne search the day before. Unfortunately, because of morning fog during all three exercise days, less than half of the scheduled airborne measurements could be performed each day, so the co-operation between airborne and car-borne teams could not be fully realized.

2.2. Radiation safety

According to the LIVEX scenario the source nuclides should be unknown and the sources hidden, buried or in other ways difficult to find and to identify. The follow-up of sources on the ground required search teams to get close to hidden sources. Since sources were supposed to be located by measurements of the radiation field and not by eye, the sources could not be visibly marked. Therefore special safety arrangements were put into practice to allow the managing personnel and the search teams to operate safely in the search areas with hidden sources. The Swedish Radiation Protection Authority stated conditions for the use of the radiation sources in the exercise and issued the permission for the exercise according to the Swedish legislation. Special arrangements were put in place in the weeks before the exercise so that the sources could be managed with minimal doses according to the ALARA principle. The arrangements had to ensure that doses to search teams or to the public by mistake were avoided. The sources were placed within physical barriers of different kinds to prevent people and animals coming into contact with them. Access to the exercise grounds was legally restricted and physically prevented by roadblocks. Military radiation protection personnel guarded the areas around the clock. Identification procedures with special car signs and personal identification tags were implemented to ensure that only the approved search teams taking part in the Gamma Search Cell exercise had access to the exercise grounds.

All persons participating in the Gamma Search Cell exercise had to carry dosimeters. These were supplied by the exercise management at the start of the exercise and collected after the exercise. Teams could also use their own dosimeters, but it was obligatory to carry the special dosimeters supplied by the management. In addition, all participating search teams were encouraged to use dose rate instruments. One specific person was assigned the responsibility for radiation safety.

2.3. Radiation sources

The sources were borrowed, rented or bought from national institutions and companies handling radioactive sources. These were the Swedish Armed

Forces, radiography companies, laboratories and one hospital. The sources used were 24 ^{60}Co, 11 ^{137}Cs, two ^{99}Mo, two ^{192}Ir, one ^{131}I, one ^{241}Am and three blocks of stone with natural uranium ore, for a total of 44 sources ranging in activity between 0.0004 and 41 GBq.

The sources were placed in shelters, sheds, vehicle carts, cages or free air, with special arrangements for the radiation protection requirements. The positions of the radiation sources were determined by handheld GPS equipment. Most of the sources were shielded in various ways. Up to 15 t of concrete filled boxes were used to build shields for protection and to create confusing radiation fields.

In some cases two sources were combined only one of which was supposed to be measurable from the air. If and when a car-borne search team entered the area to verify the air finding, they were supposed to find another source, positioned some distance away. The sources 4:2 and 4:3 and the sources 4:6 and 4:7 were arranged according to that idea.

Other combinations of sources were also made especially for car-borne teams. At some locations two sources were placed within a distances of 20–40 m. One source could generally be found from the car, but the second could only be located by a survey on foot in the surroundings. The sources 2:1 and 2:2 and the sources 4:4 and 4:5 were of this kind. The twin sources 7:3 and 7:4 were collimated towards each other to remove the effect of the inverse square law.

In search area A5 the source 5:4, a ^{137}Cs source of 1.9 GBq, was placed in a trailer and pulled by a car on a closed road of about 4 km length. This source was only intended for airborne search.

2.4. Radiological Emergency Assessment Centre

The search teams were led from a command and control centre named the Radiological Emergency Assessment Centre (REAC) that was established with the help of military resources in Boden in the week before the exercise. Both civilian and military personnel staffed the centre. It directed the search teams and handled the safety of the teams. The REAC also received, processed and displayed the radiation measurements from all teams. The military Air Wing handled air control and safety for the airborne teams. Places for liaison officers for Russian speaking teams were provided in the REAC and the Air Wing. About 30 people worked in the command centres during the exercise days.

The task for each team was to determine the position, radionuclide, activity and dose rate of as many sources as possible within the assigned search area and time allotted, and to report the findings as soon as possible to the

REAC. Helicopter teams had to report source findings to the REAC within one hour after landing. Car-borne teams had to report source findings as soon as possible after a source was located.

Source findings had to be reported in a specific form, the Source Identification Report. Reporting could be made by telephone, fax, radio or e-mail to the REAC. Track measurement data could be reported on data media or by e-mail in the NKS format, which had been designed for mobile measurement data and was first used during the RESUME 99 exercise in Gävle. In addition, teams could report more detailed measurement data if they chose.

A password protected Web site was used to display results from all participating teams in the Gamma Search Cell exercise. Each team had access to their own results on the Internet, but different teams could not see each other's results until the end of the exercise. At that time all results were made available to all participants together with details on source data. General information about teams, the progress of the exercise and other items of general interest was provided on a web site open to the public.

3. SEARCH MEASUREMENTS

3.1. Equipment

Participation in the Gamma Search Cell exercise was open to teams using fixed wing aircraft, helicopters and cars. Measuring equipment consisted generally of gamma spectrometers based on sodium iodide crystals or semiconductor detectors based on high purity germanium. One airborne team used non-spectrometric instruments based on Geiger–Müller (GM) tubes. In addition, geological survey instruments and dose rate meters were used for handheld measurements close to the sources.

3.2. Time schedule

Most participating teams arrived in Boden on Wednesday, 12 September 2001. An opening and information meeting was held on 13 September. Information on activities concerning reference measurements and pre-exercises was given on the mornings of 14 and 15 September. Detailed orders for each exercise day were given on the evenings of 16–18 September. On 16 September a pre-exercise was conducted during three hours. On the afternoon of 13 September the official LIVEX opening ceremony was held.

The main exercise took place during 17–19 September. Source locations and results from teams were presented on the morning of 20 September.

3.3. Airborne search

Helicopters were allotted to five search areas of 2 km × 5 km (A1–A5). Only one helicopter was allowed into a search area during a time slot. (A single exception was made for three Swedish military helicopters measuring in formation in area A5 during the last hour of the exercise.) The time allotted to each search area was about 50–55 minutes. During the three exercise days there were 7–8 time slots per day for each search area. However, owing to fog in the mornings, only the afternoons could be used for airborne search. The REAC provided airborne teams with maps of the search areas.

Helicopters were allowed to fly at their own choice within the borders of the search areas but were not allowed to land there. The minimum flight height was 60 m, to maintain a safe distance to the sources. There was unassigned space between individual search areas allowing helicopters to make close turns just outside the area. One fixed wing aircraft also participated (SEA). It was given time slots when helicopters were not in the air.

A specific training area 3 km × 3 km (A6) was assigned. In this area two radiation sources (^{60}Co and ^{137}Cs) were well marked and visible from the air. The training area was open from 13 to 19 September. In addition, two radiation sources (^{60}Co and ^{137}Cs) were available for reference measurements at the aviation field.

3.4. Car-borne search

Car-borne search teams were given different areas and roads to search each day. The REAC provided all teams with road maps showing search roads, search areas, and entry and exit points. Four (A1–A4) of the five search areas assigned to airborne search were also open for teams in cars and on foot with portable equipment. These corresponded to the car-borne search areas C1–C4. About 300 km of roads were available for car-borne search and were divided into five areas (C1–C4, C7). Typically 3–6 car teams shared one area. Teams were allowed to leave their car and perform search on foot in the terrain with portable equipment, except for area A5, which was only assigned to airborne search and was not open for car-borne search or search on foot.

Car-borne teams had access to radiation sources for training and reference measurement in the specific training areas at A6 and at the helicopter airfield. Access to the training area at the airfield was allowed from 13 September and at the A6 area from 14 September.

4. RESULTS

The search results for all teams are graphically presented in Fig. 1. The presentation is based on the Source Identification Reports used during the exercise and the teams' written reports. In some cases it was not quite clear if a

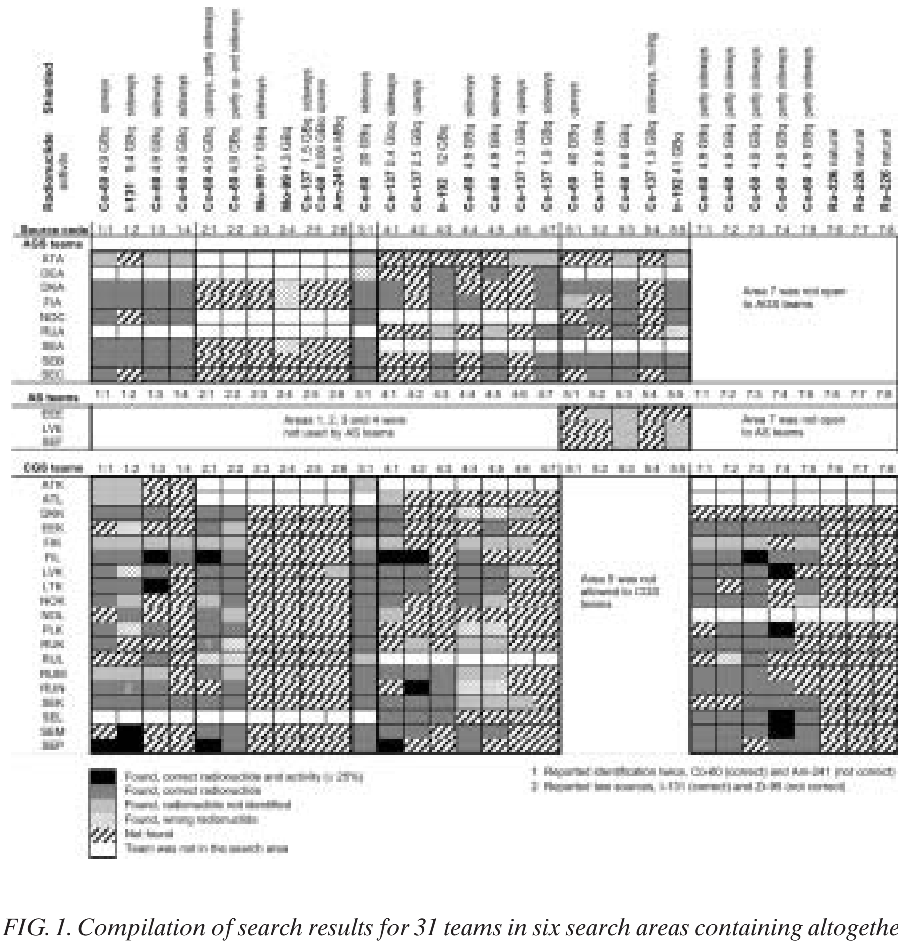

FIG. 1. Compilation of search results for 31 teams in six search areas containing altogether 32 hidden point sources of seven different radionuclides. The methods were airborne gamma spectrometry (AGS), airborne search with non-spectrometric equipment (AS) and car-borne gamma spectrometry (CGS) combined with search on foot with handheld equipment. All AGS teams but one used helicopters. The Swedish team SEA used a fixed wing aircraft. The Austrian team ATA used non-spectrometric equipment. The first number in the source code is the search area number. Detailed information on sources and full results as reported by each team are given in Ref. [1].

source had been located. For example, a source with the correct radionuclide could have been reported with co-ordinates more than 100 m off the position measured at the placement of the source. Since the uncertainty in the GPS positioning is of the order of 20 m, a judgement on the part of the authors was sometimes made to determine if a source had been found or not. By which method a source was found is not possible to see from the figure.

On the average about half of the sources were located by the airborne and car-borne teams. Some of the sources were not found at all. For example, the source 2:5 (six level indicators), with a total of 1.5 GBq of ^{137}Cs collimated upwards and 0.06 GBq of ^{60}Co collimated sideways, was not found either from the air or from the ground. The reason why it was not found from the air is probably that the beam was too narrow to be detected. A helicopter had to pass directly over the source to come into the radiation field. The reason why the ^{60}Co source was not detected by car-borne teams was the combination of the narrow beam, the low activity and the distance (about 50 m) from the road.

The source 2:3 (a hospital Mo–^{99m}Tc generator) with an activity of 0.7 GBq was also not found from either the air or the ground. In practice, it was impossible to detect from the road by car-borne measurements because of the sideways shielding and the long distance (about 100 m) from the road. This was also not the intention. The source was intended to be detected from the air with a subsequent follow-up with handheld equipment on the ground.

Three blocks of stone 7:6, 7:7 and 7:8 (about 50 kg) containing uranium ore were all placed in area C7 in wooden boxes and tied to the outside of the railings on bridges over streams. The distance to the cars passing by would have been 1–2 m. None of these sources were detected.

One airborne team detected once the moving source 5:4 in area A5 with 1.9 GBq of ^{137}Cs. Another airborne team spotted the car and trailer visually and tried to follow it along the winding road. However, the team lost sight of the car in the woods and did not report the source.

All airborne gamma spectrometry teams detected the strong sources 5:5 with 41 GBq of ^{192}Ir and 5:3 with 9.8 GBq of ^{60}Co. The source 5:2 containing 2.6 GBq of ^{137}Cs was missed by two airborne teams with spectrometers and one airborne team with a GM detector. It should normally have been detected, but it was placed only 60 m from the stronger ^{60}Co source 5:3. Therefore its radiation was ‘drowned’ in the primary and scattered radiation from the ^{60}Co source. It should, however, probably have been possible to identify with a closer analysis of the pulse height distribution from a spectrometer.

The source with the strongest output was 5:1, a 40 GBq ^{60}Co source for radiography. It was buried about 50 cm under a road, so it produced mainly scattered radiation. This source was detected by four of seven airborne teams.

The weakest source that was found from the air was 4:1, a 0.4 GBq ^{137}Cs source. Two out of seven teams reported it.

The weakest source that was found by a car-borne team was 2:6, a 0.0004 GBq ^{241}Am calibration source placed in a trailer at the roadside near the entry point to areas C1 and C2. Only one team located the source. This was done using handheld equipment. The trailer was searched because the team had decided to make measurements near all vehicles in the designated search area.

The total results are summarized in a very simple way in Fig. 2. The percentage given is of the total number of possible findings, i.e. the number of sources times the number of teams looking for them. The number is corrected for teams that did not make measurements in a certain area.

The number of possible findings was 150 for airborne gamma spectrometry teams and 432 for car-borne gamma spectrometry teams. In practice the possible number of findings for the airborne gamma spectrometry teams is less than 150, owing to the fact that some sources were arranged in such a way that they could not be seen from the air.

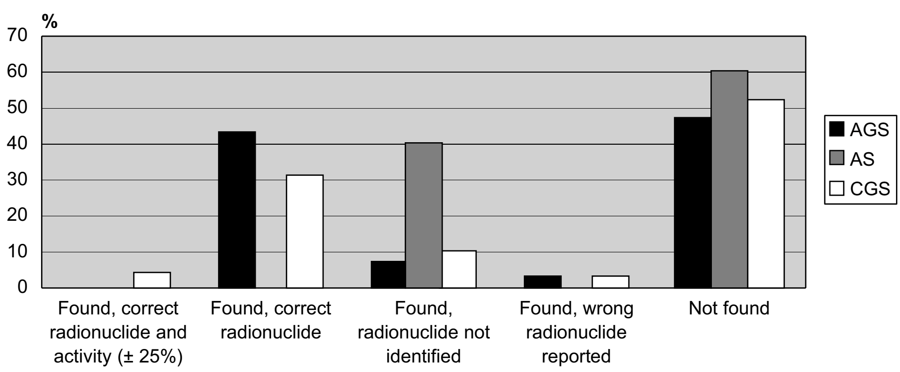

FIG. 2. Fraction of sources found using the methods of airborne gamma spectrometry (AGS), airborne search with non-spectrometric equipment (AS) and car-borne gamma spectrometry (CGS) combined with search on foot with handheld equipment. AS was only performed in one search area (A5) owing to time limitations.

5. DISCUSSION AND CONCLUSION

5.1. The exercise

It is a difficult task to find and identify hidden radioactive sources; the results of the Barents Rescue Gamma Search Cell exercise clearly indicate that. It is of course possible that in a real accident the source activities would be stronger and the search teams would know which radionuclide and what source type to look for. Nevertheless, the exercise gave the participating teams a good opportunity to practise and to test their equipment and search strategies.

Most teams found it very valuable to have their equipment tested under field conditions, mounted in vehicles and bumping around on gravel roads or in helicopters and with limited time at their disposal. Many problems had to be dealt with, such as the broadening of full energy peaks and optimization between detector systems. Other examples of problems were background discrimination, how the system alerts when passing a source, online or post-processing of data and accurate positioning. No team found all sources, and a few sources were not found at all. The results for the different teams show great variety, but every team found at least some sources.

The mornings during the three exercise days were too foggy to allow flying in the area. Therefore there was a shortage of available time slots for flying compared with what had been scheduled. This affected the results because all teams did not get suitable time slots to cover all search areas. This in turn hampered the planned co-operation between air search teams and ground search teams.

The ‘twin sources’ 2:1/2:2 and 4:4/4:5 were placed close together. In several cases just one of them was reported. For air search it is understandable that it is difficult to separate two sources of the same kind. Car search teams, however, should have a search strategy that ensures that sources that may be located close to a found source will also be found.

Just as had been planned, some sources that were found by car-borne search did not turn up in the air search reports and vice versa. This is important knowledge from a preparedness point of view. To find all sources, complementary search methods must be used.

It is necessary to use spectrometric equipment to identify radionuclides, but it seems to be difficult and time consuming to estimate the source activity, and none of the air teams managed to do it. Good knowledge of parameters such as dose rates, distances and thickness of shielding is necessary, something that is very difficult to obtain through airborne search alone. Car-borne search teams that have been successful in estimating the activity have used a combination of methods to gain knowledge of these parameters. Often one can use dose rate meters to estimate the distance to the source by using the inverse square law. By analysing the relation between the full energy peak and the Compton continuum in the pulse height distribution one can probably get some idea of the thickness of the shielding.

Car-borne search teams have reported that some sources were found with methods other than radiation measurements. In some cases teams looked for signs other than radiation, for example suspicious buildings. So the fact that a source is reported as found does not necessarily mean that something can be said about the effectiveness of the equipment used.

Many computerized programmes exist for analysis and presentation of data. An evaluation of their functionality when used by more or less experienced operators, sometimes under stress, could be wise to perform. The fact that different teams and nations use different programmes makes co-operation and exchange of data and results more difficult. Standardization would facilitate information exchange.

A more detailed and systematic analysis of the methods and equipment by which sources were found would show whether large detectors give better results than small detectors, or if one detector system or method is better than another. This can be an issue for future work to improve preparedness for radiological emergencies.

5.2. Post-exercise seminar

A follow-up meeting for all participating teams was held at Rosersberg in Sweden on 23–24 October 2001. At this meeting participants presented their measurements and discussed experiences from the exercise.

A common opinion of the teams was that airborne and car-borne gamma spectrometry is important for the search and identification of orphan radioactive sources in a radiological emergency. The teams felt that they were able to find and identify lost sources, but that the search might not be effective in all situations. Success will depend on a number of factors, such as the expected radionuclide, source activity, shielding and distances to sources, and also on sheer luck. Reporting should cover not only the position, radionuclide and activity of a source but also other important quantities and observations, such as uncertainty, beam direction, dose rate as a function of distance, and safe distances.

Some teams pointed out that their online analysing procedures needed much manual attention and that the operator became very tired after hours of work. This could lead to missed sources. Better software is needed for online and post-processing, with minimum operator interface. Equipment with alarm triggers, for example sound, will improve the effectiveness.

The teams pointed out that when units from different organizations are working together, there could be problems with the reporting and exchange of information owing to different systems and different ways of presenting measured data. It is important to have standardization of the reporting and to have good practices for data evaluation and presentation.

In the case of a radiological emergency, search teams will need accommodation, food, communication equipment, and technical and scientific support. There should be a command and control centre established in the area (like the REAC). Airborne gamma spectrometry could be effective for scanning areas, although shielded or weak sources might not be detected from the air. Car-borne gamma spectrometry is best suited for search along roads and for local follow-up of findings from the air. Co-ordination between airborne and car-borne teams is important. Possible mobile sources will be difficult to find. A large number of personnel will be needed, both for the field operations and for the analysis in the command centre.

It was concluded that all teams were satisfied with the exercise and that future development would benefit from further co-operation between the authorities, institutions and teams that have the task of locating lost sources in the event of a radiological emergency.

ACKNOWLEDGEMENTS

The Swedish Rescue Services Agency (SRV), the Swedish Radiation Protection Authority (SSI), the Swedish Defence Research Agency (FOI) and the Swedish Armed Forces (FM) were responsible for planning and conducting the Gamma Search Cell exercise in the Barents Rescue LIVEX 2001 exercise.

Nordic Nuclear Safety Research (NKS) supported participating teams from the Nordic countries. NKS collected measurement information from all teams to facilitate a subsequent scientific evaluation of measured results. Generally all participating teams have allowed the use of all data that have been reported and documented. When using data from other teams in scientific reports, these teams should be duly referenced and acknowledged. The detailed team's reports are published in the report NKS-54 [1], which is available from Nordic Nuclear Safety Research.

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DISCUSSION

S.B. ELEGBA (Nigeria): Could you say something about the relative effectiveness of the car-borne search method and the airborne method.

T. ULVSAND (Sweden): With the airborne method, 50% of the sources were found, of which 8% were not identified. With the car-borne method, 45% were found, of which 10% were not identified. Some sources were arranged in such a way that they could be found by either method.

S.B. ELEGBA (Nigeria): What was the typical volume of the NaI crystals used?

T. ULVSAND (Sweden): For handheld spectrometers it was 0.7 L and for car-borne ones it was 4 L, but there were crystal volumes going up to 16 L.

S.B. ELEGBA (Nigeria): Is the detailed NKS-54 report available on the Internet?

T. ULVSAND (Sweden): Yes, at www.nks.org.

K.S. PRADEEPKUMAR (India): If an airborne system can find and identify a source, it should not be very difficult to estimate the source strength by making the helicopter hover right above the source.

T. ULVSAND (Sweden): If there is time for the helicopter to hover, the possibility of estimating the source strength will of course increase. However, you need to know about, for example, the source shielding, and you also need to consider whether you are making the best use of the available time.

K.S. PRADEEPKUMAR (India): In my view, a car-borne system has the disadvantage vis-à-vis an airborne system that it may be hampered by the topography or by intervening buildings.

T. ULVSAND (Sweden): Of course, sources may be hard to find if they are, for example, a long way from the road which you are using. During the exercise which I described; however, some such sources were found through the car-borne search but not through the airborne one.

V. KOSENKO (Ukraine): Did all the search teams have to follow the same search strategy?

T. ULVSAND (Sweden): No, each team was free to choose its own strategy. The teams were required only to keep within the time allowed and within the assigned areas.

METHODOLOGIES AND SYSTEMS TO MEET THE CHALLENGES OF LOCATING AND RECOVERING ORPHAN SOURCES: SOURCE SEARCH OPERATION CONDUCTED BY FRENCH AND INDIAN TEAMS IN THE REPUBLIC OF GEORGIA

P. FRACAS*, G. KRISHNAMACHARI**, J.P. GAYRAL*, M.S. KALE**, P. CHAUDHURY**, K.S. PRADEEPKUMAR**, D.N. SHARMA**, V. VENKAT RAJ***, R.S. DESHPANDE+

* Commissariat à l'énergie atomique,
Fontenay-aux-Roses, France
E-mail: patrick.fracas@cea.fr

** Radiation Safety Systems Division,
Bhabha Atomic Research Centre,
Trombay, Mumbai, India

*** Health Safety and Environment Group,
Bhabha Atomic Research Centre,
Trombay, Mumbai, India

+ Permanent Mission of India to the
International Organizations in Vienna,
Vienna

Abstract

Radioactive sources are finding wide ranging applications in medicine and industry apart from their use in research and agriculture. Thus the use of a large number of radioactive sources of varying strengths is increasing at a fast rate in many countries the world over. Having effective regulatory control and ensuring the safety and security of such sources is essential. Sources lost, misplaced or stolen may pose a serious threat to humans the world over, as this may lead to inadvertent exposure of the public. Concern over the possible threat due to these orphan sources necessitates the development of systems and methodologies to identify and locate such sources and also gives rise to the need to be in a state of readiness to respond effectively to radiation emergencies involving them. Apart from the instruments developed locally by many countries, equipment is commercially available that allows effective survey and detection of orphan sources. Specific strategies have to be developed for effective searches and for source management that suits individual countries depending on their regulatory and control measures, topography, availability of resources, technical capabilities, etc. Extensive international experience has also been accumulated with respect to searching for, locating and securing orphan sources. The paper describes the general approach to defining a strategy for the detection and location of orphan sources, and the systems and methodologies developed by French and Indian teams that are kept in readiness for the prevention of illegal trafficking as well as for searching for and locating orphan sources. The paper also discusses, as a case study, the source search operations carried out, under the auspices of the IAEA, by French and Indian teams in the Republic of Georgia in the years 2000 and 2002.

1. INTRODUCTION — IDENTIFYING THE CHALLENGES

Millions of commercial radioactive sources in the world are finding wide ranging applications in medicine and industry, apart from their use in research and agriculture. Each State should apply existing rules for their proper and safe management. When this is not done, the local authorities might have to deal with one or more of the following situations:

— The sources could be misplaced or lost (sometimes with malevolent intent).
— They could be voluntarily disposed of.
— They could be illicitly trafficked.

Usually the sources placed in these situations are called orphan sources.

It is reported that, within the last few years, many radioactive sources have been lost or misplaced in certain countries/regions. These sources pose a radiological risk to humans the world over [1]. The possibility of radioactive sources being stolen or illegally brought into any country also cannot be ruled out. Among the sources used worldwide, a fraction, estimated to number in the thousands, have been orphaned owing to the lack of regulatory control in some countries. It is estimated that the regulatory control is weak in approximately 100 States, about 50 of which are not Member States of the IAEA.

Though the controls have improved, every year many sources continue to be lost, abandoned, stolen or improperly disposed of, and these can pose a public health threat if unsuspecting people encounter them. For example, within the European Union, an estimated 70 sources are lost annually from regulatory control.

The lack of appropriate controls leads to radiological accidents. Some of these have had serious consequences, including the death of several exposed persons as well as environmental effects and serious economic consequences.

Therefore, if a State knows that orphan sources do exist on its territory, it must try to bring them under control again, with priorities based on the severity of the potential radiological hazards due to these sources. Each country has to organize and customize its response to situations involving radioactive sources according to the level of the problem it has to cope with, for safety and economic reasons. Locating and securing orphan sources is not a simple task; it requires financial resources, appropriate organization, careful planning and preparation, provision of equipment and training, etc.

This paper describes the general approach to defining a strategy for the detection and location of orphan sources, and the systems and methodologies developed by the French and Indian teams that are kept in readiness for the prevention of illegal trafficking as well as the search for and location of orphan sources. The paper also discusses, as a case study, the source search operations carried out, under the auspices of the IAEA, by French and Indian teams in the Republic of Georgia in the years 2000 and 2002.

2. GENERAL APPROACH

2.1. Assessment of national situation and objectives

Regaining control over all orphan sources is an ideal outcome for a State, but there is no ideal solution to the management of orphan sources. Therefore in determining an overall strategy the State will need to assess the benefits and detriments of various options and to eventually find a compromise. Each State has to consider and then specify what its priorities will be. This political decision will require the following technical basis:

— The knowledge, even incomplete, of the current situation in the State, i.e. the degree of severity of the problem;
— The objectives the State wishes to aim at, which can be expressed by the definition of what has to be detected.

For both these aspects, criteria and parameters must be established. The first stage is to assess the current situation to get an overall picture of the problem in order to decide a strategy considering the following:

(1) The potential number of orphan sources to be searched for in the country concerned is based partly on the following:
    — The identification of potential users and potential facilities where sources could be used (various IAEA-TECDOCs give lists of potential uses of radioactive sources, e.g. Refs [2, 3]);

— Information available to the authorities on locations where sources were or may be present, reported incidents, etc.;
— The different radionuclides and the associated activities;
— The estimated number of imported radioactive sources;
— The sources declared as lost or stolen.

(2) The number of persons (workers or members of the public) to be involved in the search and the extent to which they may be exposed.

(3) The situation of the neighbouring countries. In cases where the neighbouring countries do not have an efficient regulatory infrastructure, this might give rise to an incoming traffic of orphan sources which should be prevented.

The second stage consists in defining the objectives the State wishes to aim at. They can be defined by different factors, including:

— The nature and type of sources to be detected;
— The level of activity to choose for searching for orphan sources.

These objectives have to be assessed realistically and not optimistically, and to be balanced against the associated means the State could deploy to reach them.

2.2. What to search for?

Generally it is admitted that according to the available technical, financial and human resources, it will not be possible to look for all the orphan sources potentially present in a country. So each State should decide on an acceptable level of risk which will correspond to values of activities of radionuclides above which the State should provide the resources to guarantee detection.

It will be obvious that a high level of radioactivity which has the potential for causing significant harm to persons in the short term or which leads to large scale contamination of the environment must be considered first. For the other categories, a minimum activity level has to be defined as a detection limit. Such a decision is fundamental and is indispensable before undertaking any planning operation, because this definition of a level of activity will lead to the definition of a limit of detection, and therefore will determine the detection equipment to be used for a given zone to be investigated and the grid to be followed by the search teams.

2.3. Where to search?

After the current situation and the objectives have been established, it will be necessary to organize the search plan. There should be a final list where the sources which were used or supposed to have been used (radionuclide and activity) are mentioned.

Here again it will not be acceptable to decide randomly what will be the order of the locations to be searched. To classify the locations to be searched, some criteria should be drawn up, such as the activity of the source and the density of the population of the area. A local visit should allow verification of whether the expected sources are still under control. If not, the location should be entered in the list as one to be searched. This will allow a prioritized list to be drawn up of the locations to investigate, and for each location the activity of the radionuclide to be searched for will be mentioned. This list will be the basis for organizing the search plan.

2.4. Defining a search plan

The basic requirement of a search plan to perform such an investigation is a search team that is organized, trained and sized according to the conclusions of the previous analyses. The number of team members should be decided on the basis of the number of locations to be investigated and the programme established, and should take into account the priorities and the period of time allowed for the search. In the same way, the training of the team members and the nature of the equipment employed (detectors and dosimeters) should be adapted to the kind of sources to be searched for and the associated risks. It will be essential to recruit radiation specialists to be part of the team, or at least to organize the team in small groups of searchers headed by such a specialist. Administrative requirements and clearances should be established to give a legal status to the survey.

3. SYSTEMS AND METHODOLOGIES AVAILABLE

3.1. Installed γ or neutron radiation monitors

Installed γ or neutron radiation monitors working in real time are designed to automatically detect the presence of radioactive materials or sources being carried by pedestrians or transported in vehicles, in order to keep a check on any unauthorized movement of nuclear materials or sources [4, 5]. These types of radiation monitors are often known as portal monitors and typically consist of an array of detectors in one or two vertical pillars with associated electronics. The instrument sensitivity is strongly dependent upon the distance, volume of the detector and monitoring time [6]. The detection of sources in vehicles is difficult owing to the inherent shielding of the vehicle structure and its components. Careful consideration should therefore be given to selecting the optimum location to install fixed radiation portal monitors so that they can be most effective. It is necessary to place the instrument at a location where the speed of the vehicle is controlled and reduced.

The cost of equipment is negligible considering the seriousness of the problem, and the State must balance the amount it is prepared to invest against the objectives it is aiming at. The following should be considered by the authorities in charge to identify the best location from the point of view of the efficiency of the detection of orphan sources:

— When a radioactive source is no longer in use and is not under proper, qualified supervision, it could be abandoned without any special warning signs on it and treated as waste. In that case, and depending on its size or its appearance, it might enter into a recycling process, with the risk that it will be burnt or melted and then dispersed. Of particular interest in this connection are scrapyards, garbage areas, foundries, steel plants, etc.
— When radioactive sources are lost from normal control, they can either remain on the territory of the State or can be moved out without any malevolent intention. If the probability of these events is significant and if the locations of the potential border crossing points can be identified, it would be useful to consider the detection of such traffic, in which case not only road and railway border crossings should be considered but also railway stations, seaports and airports.

When a programme is formulated to detect orphan sources, it is essential to try to detect them at places where sources could be inadvertently disposed of, such as scrapyards, foundries and garbage areas. The entrance gates of such places should be equipped with the appropriate detectors.

3.2. Transportable γ radiation monitors

Three types of γ radiation detectors can be used [7, 8]:

(a) *Surface stationary installations.* This is the same type of equipment as the installed system but the detectors are generally smaller and they can be put close to the sample for control. For example, the equipment can be accommodated in a crane and the display and operation can be controlled by a portable computer. The advantage of this is that a smaller source can be detected, as the shielding within a load of ferrous scrap is much less than in a full vehicle load.

(b) *Vehicle mounted systems.* Generally large detectors are used together with automatic data logging of gross count rate and dose rate, along with positions derived from the Global Positioning System (GPS). One such system developed in India is the Environmental Radiation Monitor with Navigational Aid (ERMNA), which can be used for mapping the environmental radiation background [9]. ERMNA is mounted in a suitable vehicle and the survey route is planned according to whether the survey is to be conducted to search for an orphan source or for large area contamination. The radiation mapping of the route followed by the vehicle is achieved by recording the γ dose rate data tagged with positional co-ordinates on a real time basis. Since the railway system has a very large network in India, mapping along the rail routes will cover a significant portion of the Indian landscape [10]. The Aerial Radiation Counting System (ARCS) made in the United States of America has multiple detectors of various sizes, including a 16 L Geoline NaI(Tl) detector, and the system records gross count rate along with positional co-ordinates. The γ count rate profile of the route followed by the vehicle helps to locate the orphan sources.

(c) *Airborne systems.* Airborne systems use larger detectors than other systems. They can be used to search for distributed activity due to accidents and also for single sources (see the example of airborne detection systems described in Sections 4.4 and 4.5). Their advantages include the ability to cover a larger ground area quickly, but in an urban area, where structures are higher than two floors, the effects of shielding and geometry can significantly limit the detection level.

3.3. Portable γ radiation monitors

Handheld γ radiation monitors use very small detectors; they generally indicate counts per second and have an audio output to identify changes in count rate by varying the pitch of the note generated. These detectors are very sensitive and can be used to locate a source in a large volume.

4. OPERATIONAL EXPERIENCE: THE CASE STUDY OF GEORGIA

4.1. Orphan sources in Georgia and international assistance

Radioisotope sources were used at different locations in Georgia when it was a part of the Soviet Union. A few radioisotope thermoelectric generators (RTGs), intended to serve the radiorelay system between the Ingouri hydroelectric station and the Hudoni hydroelectric station, which were then under construction, were brought into Georgia in the early 1980s. In these generators, ^{90}Sr sources of ~30 000 Ci (1 Ci = 37 GBq) strength were used as the heat generating elements. After the stoppage of construction of the Hudoni hydroelectric station, the radiorelay system lost its utility and these generators were left without supervision and control. As a result, by the end of the 1990s, these generators had been inadvertently disassembled and the sources were exposed and displaced from their initial locations.

Cases of radiation exposure due to orphan sources were first reported from Georgia in 1997 [11]. The local authorities requested international assistance for the first time in October 1997, when a group of guards in Lilo, near Tbilisi, became ill and showed signs of radiation induced skin disease. The cause of the exposures was found to be several orphan sources of ^{137}Cs and ^{60}Co of varying activities. In July 1998, three more abandoned sources with activities of 50, 3.3 and 0.17 GBq were found in Matkhoji, a village about 300 km west of Tbilisi. Another site close to Kuthaisi was discovered that contained an area contaminated with ^{226}Ra, and a military base in the city of Poti was found to contain two other radioactive sources buried in a sand floor. On 21 June 1999, a ^{60}Co source of around 37 GBq was found buried below a road close to the botanical gardens in Tbilisi, and on 5 July 1999, two ^{137}Cs sources were found in the town of Rustavi, close to Tbilisi [11].

In October 1998, two powerful sources were discovered in Khaichi, in western Georgia. The sources had been used in thermoelectric generators, of which eight had been placed in the region. These generators originally contained an activity of between 740 and 5550 TBq. Four of the generators have been located and are now in safe storage. One was recovered from the bed of the Ingouri River, which flows through this region of western Georgia. Three cases of inadvertent exposure causing radiation burns were reported in December 2001. The IAEA initiated and pursued a concerted effort to trace and recover these radioactive sources and to bring them under regulatory control. Many countries, including France, Germany and India, offered medical assistance to the radiation victims of Georgia under the WHO-REMPAN programme.

4.2. Defining the strategy for the source search operation in Georgia

If we analyse the example of Georgia, we find that the State has no regulatory infrastructure for maintaining inventories and ensuring control of radioactive sources which are used and stored on its territory, so there is no precise information available to establish a list of missing sources and their last known location. Since it would understandably not have been advisable to search randomly in Georgia for radioactive sources, to optimize the use of resources allocated by the Member States it was proposed that investigations be carried out in Georgia to:

— List all the relevant facilities, establishments, barracks and military camps;
— Identify which among them had radioactive sources in the past, and if such information was not available, to identify those which could have had such sources.

To implement these investigations, we needed to use intelligence which would help us to identify known sources or suspected sources that could have been transferred or stocked, and also supposed sources that could have been introduced into the country. To complement this information, we could also integrate information coming from the following searches:

— A search to check, in the statistics of the customs offices, the existence of imported sources. For each import, the potential user was to be identified and contacted in order to learn if the source was still under the user's control. If not, the source was to be listed as missing, and was therefore to be searched for.
— A search to identify, from previous commercial exchanges, the providers or manufacturers of radioactive sources, or of equipment including such sources. Their buyers list could contain information on Georgian users. Again, a check could help in deciding whether a source was to be searched for or not.
— A search to identify hospitals that might have been known for treating cancers and to learn whether they still possessed any cobalt therapy equipment, etc.

For each establishment identified, the potential source which was used or supposed to have been used (radionuclide and activity) had to be listed. Finally a classified list had to be established according to the probability of finding sources in these locations.

As no such information was available, a strategy was proposed to Georgia that consisted in checking that the population living in areas specified by the Georgian authorities was not exposed above the limits specified by those authorities. In May–June 2000, the searches were focused on locations where the population density was fairly high.

4.3. Airborne search campaigns in 2000

4.3.1. Equipment used and objectives

To respond to a request made by Georgia in the framework of the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, the IAEA itself requested the assistance of Member States to support the search for the missing sources. The French authorities designated the Commissariat à l'énergie atomique (CEA) to respond to this request. The CEA used airborne γ mapping equipment called HELINUC developed by CEA engineers [12].

The principle of the measurement consists in using, on board a light helicopter (Fig. 1), the appropriate means for the simultaneous acquisition of γ spectrum and the position of the aircraft in space, given by a GPS device. The

FIG. 1. Georgian AVIACOM helicopter with HELINUC airborne γ mapping equipment.

data acquired in flight are processed on the ground by a dedicated data processing system and are supplied in mapping form with dummy colours representative of the activity levels [13, 14].

The detection device comprises a set of two packs of four sodium iodide crystals with a total volume of 16 L. The acquisition time varies from 1 to 3 s. HELINUC is used to generate a radiological diagnosis with a sensitivity ranging from the natural radioactivity level to that of a severe accident situation.

The flight parameters for the helicopter were fixed in accordance with the sensitivity of the detection system, the period of time for which the detection system was made available, the populated areas to be surveyed and the exposure level accepted by the Georgian authorities. A compromise was found concerning the limiting level of activity for the population. The Georgian authorities decided 185 MBq of ^{60}Co (5 mCi) and 250 MBq of ^{137}Cs (7 mCi) to be the minimum activities to be detected. These levels of activity helped in the definition of the flight parameters of the aircraft provided by the Georgian authorities. Around 80 flying hours were needed for the helicopter to survey 1200 km^2.

If the level of activity had been fixed, for example, at 37 MBq (1 mCi) of ^{60}Co (a factor of 5 less), 320 h (4 times more) flying time would have been needed to survey the same area. In contrast, if the level had been fixed at 370 MBq (10 mCi) of ^{60}Co (that is to say, a higher risk for the public if exposed to such a source), around 40 h (a factor of 2 less) would have been needed to survey the same area. This shows the sensitivity of the level of activity to be established, and the potential consequences for the search plan.

4.3.2. Results of the aerial survey

The survey carried out with the HELINUC system resulted in the mapping of 26 zones representing the 1200 km^2 investigated (Fig. 2) during 80 h, with more than 100 000 spectra recorded. This operation led to the detection of a point source of about 75 GBq (2 Ci) of ^{137}Cs in a densely populated area near the city of Poti. In addition to the detection of this point source, the following were found:

— The average of ^{137}Cs fallout resulting from the Chernobyl accident measured in the zones flown over during this survey is of a level equivalent to that measured in Europe.
— The detection of uranium concentration anomalies indicated variations in soil composition between different regions of Georgia.

FIG. 2. Flight zones over western Georgia.

4.4. Preparation and training for the phase I source search operation

During 3–6 June 2002, the Georgian team members from Nuclear and Radiation Safety Services (NRSS) of the Ministry of Environment and Natural Resources of Georgia were trained to operate the airborne γ spectrometry system (AGSS) and other radiation survey equipment. One scientist from NRSS was trained by experts from India and another by experts from the USA to operate the AGSS and the ARCS and to interpret the data collected by the systems. About 30 persons belonging to the Civil Defence and Emergency Situations section of the Ministry of Internal Affairs of Georgia were trained by experts from the IAEA, France and Turkey to operate the French made handheld digital radiation count rate meters and γ dose rate survey meters, and to locate orphan sources.

Under this training programme, to simulate orphan sources, ^{137}Cs and ^{90}Sr sources were hidden in different locations both inside and outside military barracks in the Tbilisi shore area. The road survey exercises were carried out around this area to identify these simulated orphan sources using an AGSS and an ARCS installed in vehicles as mobile monitors. The Civil Defence members were divided into five groups of pedestrian search teams equipped with handheld monitors and were sent in different directions in that area to locate the simulated orphan sources. In this exercise each team was able to locate and identify those radioactive sources that were hidden a few tens of metres away. The training was very successful and the trained personnel could operate independently the equipment on which they were trained.

4.5. Search campaigns in 2002

4.5.1. The AGSS

The AGSS [15–17] developed indigenously at Bhabha Atomic Research Centre (BARC), India, consists of a bank of four 3 inch × 3 inch (1 inch = 2.54 cm) NaI(Tl) scintillation detectors, a PC based 512 channel scanning pulse height analyser and a GPS device. The total system, weighing ~50 kg, works on a 24–30 V DC supply available in the aircraft. Figure 3 is a schematic diagram of the AGSS. An integrated software package using Microsoft Visual Basic operating under MS Windows [18] executes the operation of the AGSS. Depending upon the requirements, this system can be fitted into an aircraft or a ground vehicle and readied for use within an hour. The γ spectral data are tagged with real time, spectrum number and corresponding positional co-ordinates, i.e. longitude and latitude logged through the GPS receiver.

The software package developed for the AGSS is capable of correlating the spectral data with the positional inputs, and then it instantly maps the calculated activity level/counts profile online onto a stored digitized map of the area surveyed , as the survey is in progress. The simultaneous presentation of the data in this form while the survey is in progress helps facilitate the demarcation of the contaminated area on the basis of the activity levels and hot spots. During an emergency situation, this information will be highly useful for the initiation of urgent countermeasures in the area identified. The system has a minimum detectable activity of 23 kBq/m^2 for ^{137}Cs for a uniform ground contamination [19].

4.5.2. Search operation in Georgia in 2002

The phase I search operation conducted in Georgia was mainly for the detection of strontium sources. Under a collaborative effort, the IAEA and its Member States have provided the required support, with their expertise, to detect and locate orphan sources in Georgia. In the experts meeting held in April 2002, it was decided to carry out the search operation in two phases, for which India would provide the monitoring equipment and the services of its experts. As per the IAEA schedule, the AGSS from India and the ARCS from the USA were to be deployed in the vehicles for ground based surveys. The

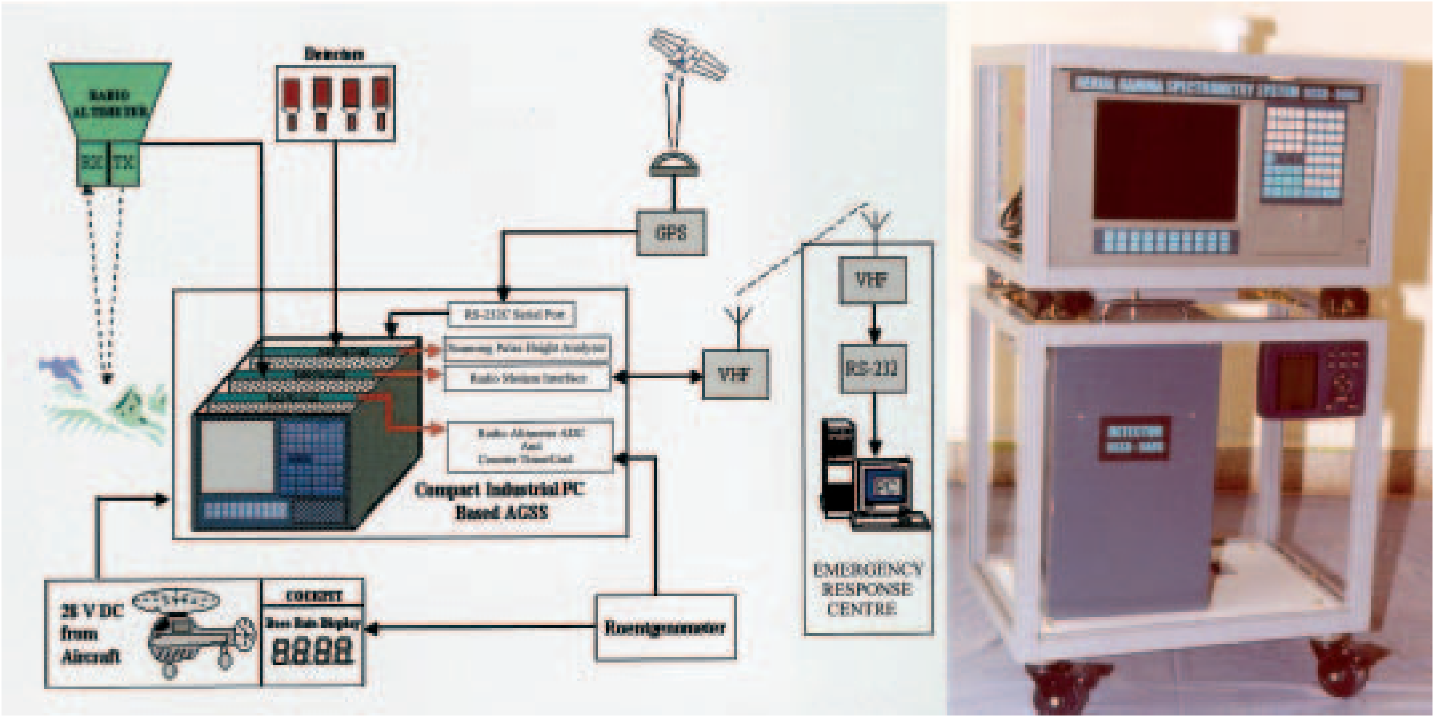

FIG. 3. The AGSS.

FIG. 4. AGSS installed in the NRSS jeep during the source search operation.

AGSS and the radiation survey instruments were sent from India in May 2002, and the Indian teams participated in the phase I and phase II source search operations during June and August 2002.

The AGSS, with its built-in vibration and shock proof trolley, was installed in a jeep belonging to the NRSS section of the Ministry of Environment and Natural Resources of Georgia (Fig. 4). The detectors, packed in an aluminium enclosure, were located in the bottom rack of the trolley approximately 1 m above the ground. Two batteries of 75 A·h capacity each, connected in series (24 V DC), were provided for powering the AGSS. The GPS patch type antenna was installed in the rear of the jeep.

The temperature was about 20–25°C during the survey period of phases I and II. The energy calibration of the system was carried out daily using standard sources before as well as after the completion of daily surveys, and no significant channel shift was observed in the γ spectrum. The strategy defined by the task groups that met on 8–11 April 2002 in Paris and on 16–20 May 2002 in Vienna and Tbilisi for the phase I and II operations in Georgia was followed for these surveys. During the surveys, on the basis of reports of the local people, additional places were also surveyed.

4.5.3. Phase I survey

The survey for the search for orphan sources was conducted around the Djvari–Khaichi–Mestia region of Georgia during 3–23 June 2002 in phase 1 of the search operation. The training was conducted during 3–8 June 2002, and the road survey for the source search operation was started on 10 June 2002, while team members were in transit from Djvari to Mestia on the main road along the Ingouri River. The speed of the vehicle was kept at around 50–60 km/h and the data acquisition time was kept at 5 s to have an approximate land longitudinal resolution of 80 m. The paths were adjacent to a hill on one side and a valley on the other, with the Ingouri River running close to the route. In the Khaichi–Mestia region, at a few locations the recorded spectra indicated a noticeable increase in total integrated counts under the energy spectrum. The background counts at these spots were about 50% more than those observed in other places. As shown in Fig. 5, the total integrated counts in counts/s for spectra numbers 2500–4000 show an increase of more than 100% compared with those observed before reaching this location, i.e. in the Djvari area (spectrum number < 2500). This region was surveyed in detail on 12 June 2002. Spectrum No. 2947 (Fig. 6), acquired during the survey of the Khaichi–Mestia region, shows traces of ^{137}Cs, ^{40}K and ^{214}Bi, a decay product of naturally occurring ^{238}U. The background spectrum acquired elsewhere is also shown to indicate the higher background at this location and the presence of the

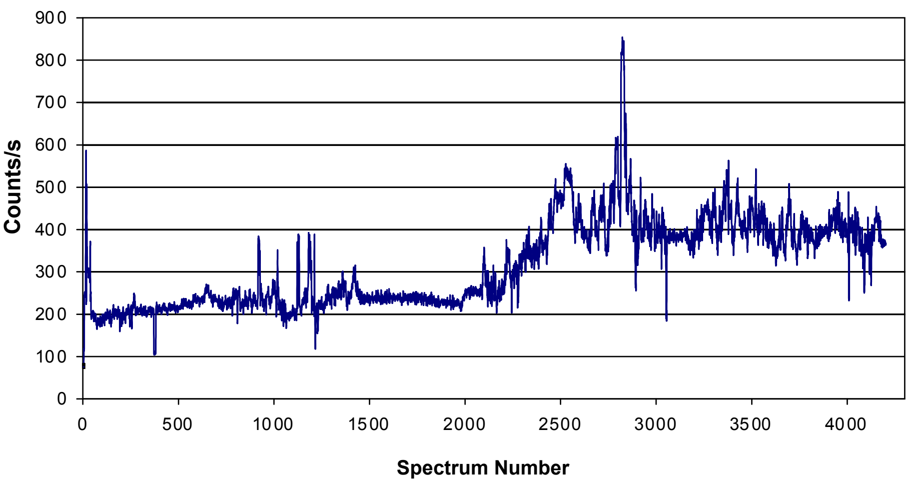

FIG. 5. Total integrated counts/s of spectra acquired during the survey of the Djvari–Mestia region (area under spectra numbers 2000–4000 is the Khaichi–Mestia region).

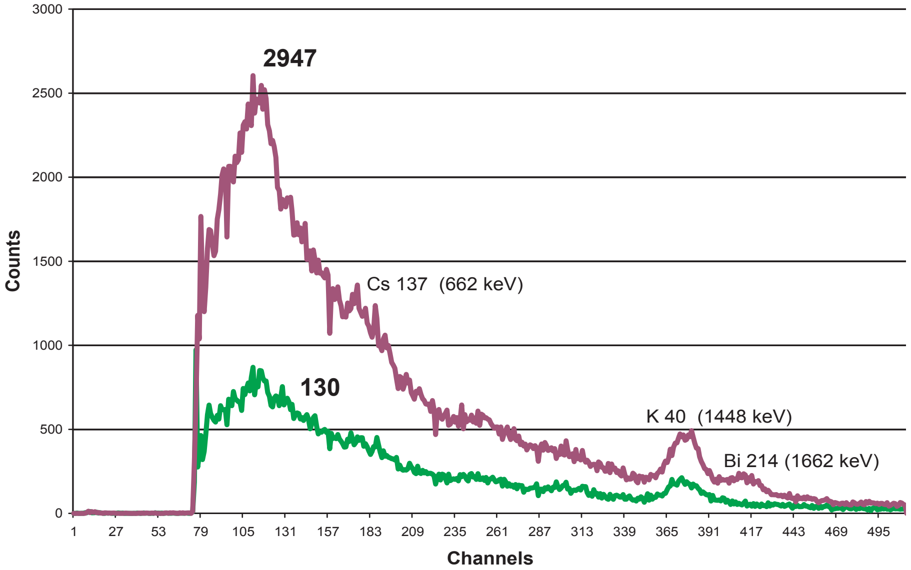

FIG. 6. Spectrum No. 2947, acquired by the AGSS during the survey of the Khaichi–Mestia region on 12 June 2002, and spectrum No. 130, acquired during a survey of a normal background area.

radionuclides. Figure 7 presents the online screen display of the AGSS for the Khaichi–Mestia region showing the acquired spectrum (No. 2947) with high background. The arrow in the figure shows the exact location at which the spectrum with higher background was seen.

From 11 to 16 June 2002 various regions of Mestia were surveyed daily. During the survey, the vehicle was moved at a slower speed of 10–15 km/h to have finer land resolution and the data collection time was kept at 5 s. The regions covered were rough road terrain. The surveyed areas showed normal background. After Khaichi, in the Khaichi–Mestia region there were many hot spots with higher total integrated counts. On 12 June 2002, the spots where higher backgrounds were recorded during the survey on 10 June 2002 were surveyed again. At all these spots, a set of spectra were acquired with the vehicle in stationary mode for a duration of 10 min. The Civil Defence team with French made handheld radiation monitors went down into the valley by rope to conduct a detailed investigation, but the team could not detect the presence of any radioactive sources. It is concluded that the presence of higher background is due to the rock deposits on the hillside with natural radionuclides. Table I shows average net counts/s under different energy windows for selected survey regions in phase I.

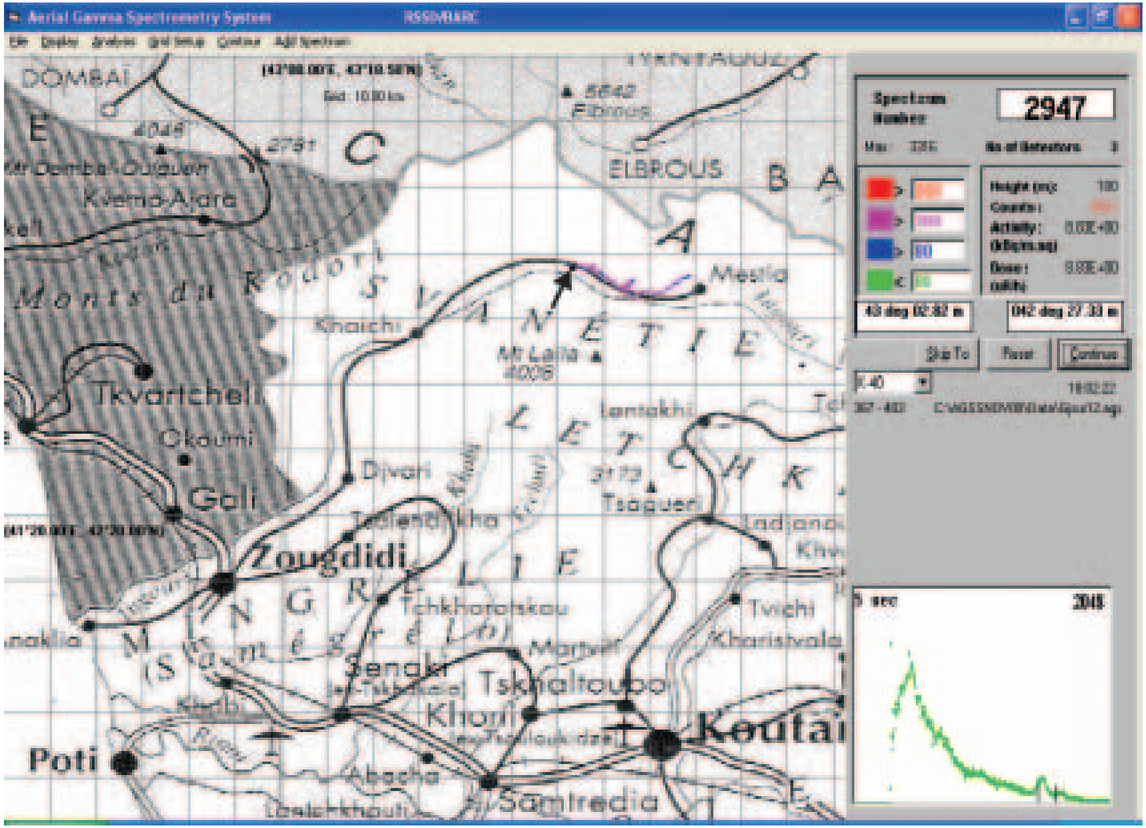

FIG. 7. Online screen display of AGSS in the Mestia–Khaichi region showing the spectrum (No. 2947) acquired with high background.

TABLE I. AVERAGE OF NET COUNTS PER SECOND UNDER DIFFERENT ENERGY WINDOWS FOR SELECTED SURVEY REGIONS IN PHASE I

SR[a] No.	Date of survey	Region surveyed	Net counts/s			Total counts/s over the entire spectrum
			Cs-137	Co-60	K-40	
1	2002-06-11	Mestia Subregion 1	36.2 ± 11.1	35.8 ± 17.27	8.0 ± 0.56	304.6 ± 102.3
2	2002-06-12	Mestia Subregion 2	40.6 ± 6.61	34.8 ± 7.49	9.7 ± 3.18	343.6 ± 54.2
3	2002-06-13	Mestia Subregion 3	51.8 ± 8.73	46.4 ± 14.10	16.0 ± 5.32	426.4 ± 70.2
4	2002-06-14	Mestia Subregion 4	46.0 ± 7.58	34.8 ± 9.44	13.6 ± 3.83	356.2 ± 64.3
5	2002-06-18	Kaichi Region 1	45.0 ± 4.99	36.8 ± 10.84	11.8 ± 4.52	366.4 ± 45.4
6	2002-06-19	Kaichi Region 2	39.0 ± 7.59	24.0 ± 4.65	7.6 ± 1.87	299.6 ± 73.8
7	2002-06-20	Djvari–Lia Region	27.8 ± 4.21	18.4 ± 3.48	6.0 ± 1.63	226.8 ± 38.4

[a] SR: search region.

On 17 June 2002 the camp was shifted to Khaichi from Mestia. During the transit, at a few locations about 20 km from Khaichi, the total counts under the spectrum were observed to be twice the values recorded earlier. It was decided by the Georgian team to conduct detailed surveys later using handheld monitors around these spots, which were identified by the AGSS to have a higher background. During 18 and 19 June the various regions of Khaichi and on 20 June the cities of Djvari and Lia were surveyed using the AGSS, but a uniform background was observed.

4.5.4. Phase II survey

The phase II road survey by the BARC team was scheduled for 14–18 August 2002 in the South Georgia region using the AGSS. The road survey

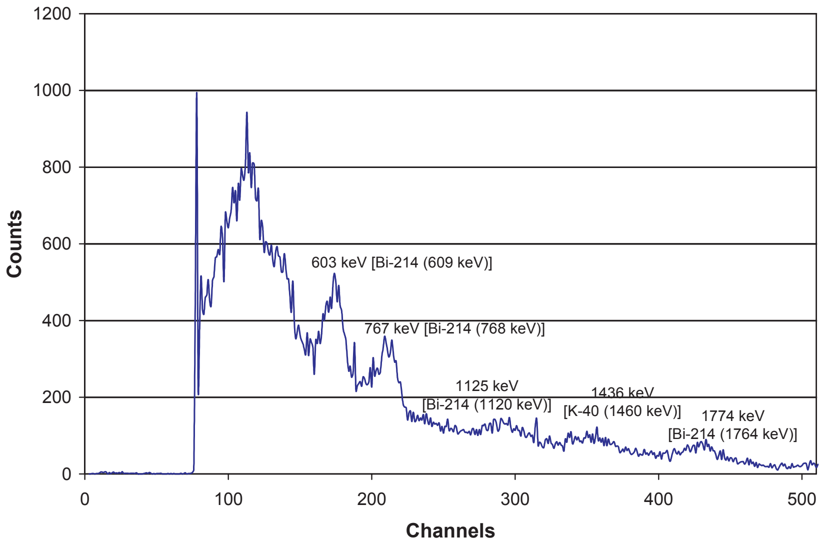

FIG. 8. Spectrum of sample collected during phase II from the abandoned airbase at Akhaltsikhe.

under this search operation was started on 15 August 2002, with the speed of the vehicle kept at around 30–40 km/h and the acquisition time for each spectrum kept at 5 s, with an approximate land resolution of 50 m.

The surveys conducted in and around the city of Akhaltsikhe during 15–16 August 2002 included some of the abandoned army bases. The outer territories of the army bases were surveyed by road using the AGSS, and the interiors of the buildings in that area were surveyed using the French made handheld survey meters in places where high readings of up to 800 nGy/h had been observed. A few samples of the scrap materials present at these places were collected and counted using the AGSS to identify the contaminating radionuclides. As shown in Fig. 8, the acquired spectrum of the counted samples has significant counts under the region of interest (ROI) of energies — 603, 767, 1125, 1436 and 1774 keV. These were attributed to the presence of ^{214}Bi and ^{40}K. The spectrum acquired by the French made portable multichannel analyser also confirmed the presence of radium.

The open areas around the buildings within the abandoned airbases in the city of Akhalkalaki were surveyed on 19 August 2002 using the AGSS and the handheld instruments. In these places normal background was observed. A similar trend was observed in other surveyed locations. During 24–26 August 2002, the maximum area around Tbilisi City was surveyed using the AGSS. Table II shows the average counts recorded within various energy ROIs, i.e.

TABLE II. AVERAGE OF NET COUNTS PER SECOND UNDER DIFFERENT ENERGY WINDOWS FOR SELECTED SURVEY REGIONS OF PHASE II

SR[a] No.	Date of survey	Region surveyed	Net counts/s			Total counts/s over the entire spectrum
			Cs-137	Co-60	K-40	
1	2002-08-15	Akhaltsikhe City	22.71 ± 8.49	12.49 ± 4.73	7.24 ± 2.80	183.3 ± 33.9
2	2002-08-16	Akhaltsikhe City	32.11 ± 9.22	22.57 ± 7.00	10.53 ± 2.00	196.2 ± 24.9
3	2002-08-17	Akhaltsikhe–Akhalkalaki	26.13 ± 2.52	33.39 ± 7.88	10.04 ± 2.99	224.0 ± 25.7
4	2002-08-18	Akhalkalaki–Chkhrula	25.78 ± 5.40	33.00 ± 7.90	13.92 ± 3.19	223.1 ± 45.3
5	2002-08-19	Akhalkalaki City	34.03 ± 3.09	40.60 ± 4.86	15.99 ± 1.97	266.0 ± 23.5
6	2002-08-20	Akhalkalaki–Vardzia	32.16 ± 3.32	36.80 ± 7.59	16.05 ± 3.11	272.3 ± 20.6
7	2002-08-21	Akhalkalaki–Tbilisi	24.06 ± 5.74	30.11 ± 9.30	13.0 ± 3.65	218.0 ± 37.3
9	2002-08-23	Tbilisi–Mtskheta City	21.31 ± 5.26	16.96 ± 5.08	7.93 ± 2.47	167.5 ± 33.7
10	2002-08-24	Tbilisi City	25.00 ± 6.26	22.23 ± 7.18	10.13 ± 3.03	215.6 ± 35.0
12	2002-08-26	Tbilisi City	25.52 ± 3.95	22.83 ± 6.16	10.24 ± 2.65	199.8 ± 29.9
13	2002-08-27	Tbilisi–Kareli City	20.53 ± 3.79	22.45 ± 6.41	9.47 ± 2.55	181.3 ± 20.7

[a] SR: search region.

^{137}Cs, ^{60}Co and ^{40}K for different regions surveyed in phase II. Figure 9 shows the regions surveyed during phase I and II search operations carried out with the AGSS.

FIG. 9. Routes monitored during the source searches in phases I and II.

5. CONCLUDING REMARKS

The control of all radioactive materials is a current and ongoing concern of every State. The necessary actions are to be undertaken by each State which might have to face the problem of lost sources and regain control of them. The purpose of this paper was to propose and elaborate on some of the steps which should be taken to detect and locate orphan sources. Two of these steps are of great importance and should be the basis for any State undertaking to solve this problem. The first one is for the State to analyse its own situation and the second one is to establish a strategy before undertaking any action. It is the responsibility of the State itself to work on the first step, but for the second one it can be supported efficiently by the advice of experienced specialists from the IAEA. The survey performed in Georgia by the Indian and French teams and described in this paper is a good example of what can be done as a joint effort.

Many efficient systems for radiation monitoring are commercially available and can be used directly by trained teams for detecting radiation sources. Encouraging the State to set up a national plan to install detection equipment at key locations (near scrapyards, borders, harbours, airports, etc.) will improve the capability to locate the sources and reduce the risk of accidental radiological emergencies.

To reduce the number of orphan sources, it is necessary to carry out preventive actions, for example the following:

(a) Assisting States in setting up a regulatory infrastructure if they do not already have one.
(b) Improving the training in identification of and response to orphan radioactive sources. This will result in a reduction of radiation exposure to individuals. Making information on disposal and reuse options available to the users will increase the likelihood that surplus sources are prevented from being lost to regulatory control.
(c) Developing and implementing an awareness programme for local authorities, industrial users, doctors, etc.
(d) For the sites and sectors where the risk is high, developing and implementing a radiation monitoring programme.
(e) Reducing security risks from future radioactive sources by continuing to reduce the radioactivity levels of sources to the minimum required to perform the task.
(f) Taking into account the first principle of radiation protection: justification of the practice. The use of non-radioactive alternatives to radioactive sources must be promoted when the non-radioactive method can provide at least the same benefit as radioactive sources.

(g) Training the medical community the world over to diagnose and treat radiation exposure victims and including in the syllabus for medical graduates the topics of radiation safety, radiation syndrome, etc. Early identification of the cause of the victims' injuries may help in locating the sources responsible and in preventing further exposure.

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DISCUSSION

V. KOSENKO (Ukraine): With what kinds of instruments were uranium sources found in Georgia?

P. FRACAS (France): Uranium sources were not found — or searched for — in Georgia. We used a γ spectrometry system (NaI, with a total volume of 16 L) to record the natural background uranium activity in the soil, which varied as a function of the soil composition. The main natural radionuclides recorded were ^{40}K, ^{238}U and ^{232}Th.

T.C. KOTZÉ (South Africa): You referred to the recovery of a point source in Georgia. What happened to the source after being recovered?

S. KAKUSHADZE (Georgia): The source, which was recovered by the Georgian authorities, is now in secure storage.

D. TAYLOR (European Commission): What was the cost of the survey carried out in Georgia?

G. KRISHNAMACHARI (India): The survey was sponsored by the IAEA, which should be able to answer that question.

S.H. NA (Republic of Korea): Are airborne surveys the best way of searching for orphan sources?

A.J. GONZÁLEZ (IAEA): On behalf of the IAEA, I should like to respond to this question and then to the question of cost.

Airborne surveys may be the only way of searching for orphan sources if the regulatory authorities have no idea even of their approximate whereabouts. The search for orphan sources in Georgia was rather like looking for a black cat in a dark room when you don't even know whether the cat is there. We often encounter extreme situations where, for example, people who are long retired tell us, "I am nearly sure that the sources were left somewhere around there." In such situations, we may recommend an airborne survey as a first step.

As to the cost of the survey carried out in Georgia, much depends on what you include in your calculations. For example, do you include the value of in-kind contributions of equipment and people's services? The direct cost to the IAEA was not high — some tens of thousands of dollars. However, if the IAEA had had to pay for the work done by the very highly qualified teams from France and India, it would have been very high.

RADIOACTIVE SOURCES: SAFE AND SECURE OPERATION, STORAGE AND RECYCLING

A.I. PLATOV, N.R. KUZELEV, V.V. MELNICHENKO,
V.P. LEBEDEV, V.N. CHERNOV, B.M. VANYUSHKIN
Russian National Technical Physics
and Automation Research Institute,
Moscow, Russian Federation

Abstract

The paper analyses and summarizes more than 30 years' experience in the application of radioactive sources in radionuclide thermoelectric generators (RTGs) with ^{90}Sr as autonomous sources of thermal and electrical power (devices for which there are no suitable alternatives for use in outlying and hard to reach districts of the country), as well as in small and large industrial irradiators. To solve the problems of containing the radiation and ensuring the ecological safety and physical protection of these radioactive sources, an appropriate normative and legal base has been developed, regulating the activity of organizations concerned with all stages of handling RTGs and other types of radioactive sources. Thus for the approximately 1000 ^{90}Sr RTGs still in operation, the process of their safe removal from operation at the end of their service life for recycling and final burial has been worked out in detail organizationally, technically and technologically, but is hampered by the absence of the necessary financial resources under the economic conditions now existing in the Russian Federation.

1. INTRODUCTION

Radioactive sources are widely used in many fields of human activity. Their radiation is used for the treatment of materials and substances to produce new or changed properties and to carry out radiation therapy of various diseases. They are used also for converting the energy of radioactive decay into other kinds of energy (heat and electricity), as well as for obtaining qualitative and quantitative information about the composition and properties of materials and products, and for inspection and management of production processes.

The most active sources are used in radiation engineering:

— Radionuclide power engineering;
— Radiation technology (sources of thousands of curies[1]).

[1] 1 Ci = 37 GBq.

Highly active sources (hundreds and thousands of curies) are also used in radiotherapy and in radioactive neutron sources for nuclear geophysics — activation analysis and neutron logging.

The successes and achievements of radiation engineering in the Russian Federation are bound up with investigations in the Russian National Technical Physics and Automation Research Institute (VNIITFA), until 1989 referred to as the All-Union Research Institute of Radiation Engineering (VNIIRT).

2. RADIONUCLIDE POWER ENGINEERING

Radionuclide power engineering using ^{90}Sr radionuclide thermoelectric generators (RTGs) started in the Soviet Union in 1962. Its origin was due to the desire to utilize reactor wastes, and to the need for independent sources of electrical power in the range of a few watts for supplying autonomous equipment in outlying and sparsely populated districts.

By the mid-1970s, the scientific and technical, structural and technological problems of development and industrial production of the main elements of ^{90}Sr RTGs and of radionuclide power installations (RPIs) based on them had been solved, as had the problems of preventing radiation exposure and environmental accidents associated with their application. Production was started of a wide range of these products with electrical capacities of from several watts up to some hundreds of watts, and a nominal service life of ten years. Industrial production of RTGs and RPIs was carried out up to the mid-1990s.

The main areas of application of ^{90}Sr RTGs and RPIs are:

(a) Sources of electrical power for navigation equipment located in outlying and hard to reach districts away from settlements, on the coast and islands of the Russian Federation; in particular, about 380 RTGs now operate on navigation objects on the Northern Sea Route.
(b) Sources of electrical and thermal power for seismic measuring equipment in the seismic inspection groups which have been deployed within the territory of the Russian Federation under the Nuclear Test Ban Treaty.
(c) Sources for supplying power for special purpose equipment.

The advantages of RTGs (RPIs) include:

(1) High power and autonomous operation for a long time (in practice more than 20–25 years);

(2) High operational reliability and ecological safety throughout the life cycle, as confirmed by long term practice;
(3) Simplicity of design and absence of moving parts.

A basic shortcoming of RTGs (RPIs), which has become most urgent in the last few years, is their vulnerability, while in service in outlying areas of the country, to the possibility of unauthorized actions by malefactors, including terrorists.

Furthermore, since the 1990s, in connection with well known political and economic changes in our country, financing of work on radionuclide power engineering has been stopped. As a result, practically all the ^{90}Sr RTGs and RPIs remaining in operation (about 1000) are products which have gone beyond the nominal ten year service life.

Under these conditions, the task of ensuring radiation and environmental safety and physical protection of the RTGs and RPIs remaining in operation and containing ^{90}Sr with a total activity of about 45 MCi has become a topical problem requiring an urgent solution.

The need to solve this problem promptly, as was already mentioned, is due to the fact that the products — as a result of the specificity of their use — are essentially unprotected against unauthorized actions and actions by malefactors, even though in the design of RTGs and RPIs some measures to hinder such actions had been stipulated.

Within the framework of solving the above problem and with the purpose of answering questions connected with the handling of ^{90}Sr RTGs and RPIs at all stages of their life cycle, VNIITFA has developed, in co-ordination with interested organizations, "Regulations for the operation and withdrawal from operation of radionuclide power installations using ^{90}Sr radionuclide heat sources (RHSs)", which were authorized by the Ministry of the Russian Federation for Atomic Energy (Minatom) at the end of 1999 and are obligatory for all organizations. This document regulates the activity of those organizations connected with RTGs and RPIs at all stages, from development and manufacturing to recycling and burial.

In accordance with these regulations a total of 254 ^{90}Sr RTGs and RPIs which had reached the end of their service life were surveyed during the last three years at their places of operation from the point of view of their technical, radiation and ecological condition. The results of the inspections were presented to an interdepartmental commission for its decision on the further destiny of the RTGs and RPIs: prolongation of service life or return to VNIITFA for dismantlement and subsequent recycling of the ^{90}Sr radionuclide sources and their burial at the facilities of the Mayak Production Association.

It must be emphasized that during the inspection at their places of operation of hundreds of RTGs and RPIs which have reached the end of their lifetime, and of tens of RHS-90s which have had a service life of up to 30 years and were taken from returned RTGs and surveyed in VNIITFA, not a single RHS-90 failure (breach of capsule tightness with release of radionuclide into the environment) was observed. At the same time, a number of surveyed RTGs (RPIs) had been exposed to fire or to unauthorized dismantling, including extraction of the RHS-90 containing tens of kilocuries of ^{90}Sr.

The RHS-90 service life attained in an RTG (RPI) structure was as expected and provided experimental confirmation of a significant reserve both in radiation and in ecological safety in the RHS-90 design.

The objective factors allowing one to expect such a reserve in RHS-90 service life are:

— Technical and technological solutions incorporated into the design;
— Conditions of operation in the RTG (RPI) structure.

In the RTGs (RPIs) now in operation, in which the temperature of the hot junction of the thermoelectric converter is limited to no more than 300°C, because of the properties of the materials used, the working temperature of the surface of an RHS-90 capsule cannot exceed 400–500°C. Moreover, the RHS-90 is enclosed in the hermetically sealed cavity of the RTG (RPI) in a rare gas environment and is not mechanically loaded. The calculated value of mechanical reliability for the safety of an RHS-90 in the RTG (RPI) structure under conditions of regular operation and possible accidents (shock impacts, fire, impact of sea water) confirms the existence of a significant reserve. The process of radioactive decay of ^{90}Sr into the stable ^{90}Zr in the fuel composition matrix of the RHS-90 is not accompanied by gassing or volume changes, and the thermal loading on the RHS-90 elements decreases with time. Under such conditions, and in view of the known heat, mechanical and corrosion properties of the materials used in the active part (ceramics) and of the constructional materials of RHS-90 capsules and their double hermetic sealing by an argon arc welding method, it is clear that the time factor is not critical for the stability and safety of RHS-90s, as fully proven by experience of their actual long operation.

The limit of RHS-90 service life in the RTG (RPI) structure is set by the limit of the reduction in the thermal flux from the RHS-90, which is connected with the decay of ^{90}Sr with time, i.e. with its functional (thermal) reliability.

The above mentioned RHS-90 service life of ten years in the RTG (RPI) structure was determined first of all by the fact that in this period of time the thermal flux is reduced by approximately 22% from its initial value, and in view of the efficiency of the thermoelectric converter at the time of manufacture, the electrical output parameters of the RTG (RPI) remain at an allowable level up to the end of the specified term of operation.

An increase of the nominal and guaranteed RHS-90 service life in the RTG (RPI) structure to 25 years is now technically and ecologically proven possible. For the purpose of experimental confirmation of the radiation and ecological safety of the RHS-90 over longer periods of time, prolonged operation is proceeding.

The results obtained on the prospect for uninterrupted functioning of existing navigation systems in the Russian Federation have suggested continuation of the use of the RTGs (RPIs), including those already beyond their initial lifetime (ten years), for a further 10–20 years; this is made possible by their overhaul at the specialized VNIITFA enterprise and by modernization, including in some instances work carried out at the place of operation and the use of modern thermoelectric converters of increased efficiency without replacement of the RHS-90, with a guarantee of the necessary level of safety. The electrotechnical components of the RTGs were often replaced at the place of operation in order to ensure the power parameters required of an autonomous power supply source.

The realization of this concept has made it possible to:

(i) Prolong the period of operation of more than 100 end of service life RTGs such as the Beta-M and RPIs such as the IEU-2 for a further 10–15 years;
(ii) Ensure the return to operation of tens of RTGs (RPIs) of various types after overhaul, reusing the RHS-90;
(iii) Develop variants of the structure of basic RTGs with a service life of close to 40 years and more. In the basic RTGs, the element base, components and units taken from 'primary' RTGs should be utilized to the extent possible. The RHS-90s also continue to be used if the regular inspection at each stage of modernization gives positive results.

At the same time, it is necessary to recognize that the final stage of the life cycle of any RTG (RPI) is obligatory recycling and burial of the RHS-90 contained in it.

It is necessary to bear in mind that the weight of one RTG (RPI), depending on the type, is between 560 and 2500 kg, and taking into account the locations of their operation, this complicates and makes more expensive the work of recycling.

Mention must be made of what are, fortunately, isolated emergency instances, requiring a special approach and, of course, involving serious financial consequences. The first case was of damage to the biological shielding of one RTG in the Far East. The biological shielding was made of depleted uranium. As a result of excessive mechanical forces during transport by helicopter, there was depressurization of the radiation shielding block, which caused an intensive process of oxidation of the uranium, sloughing of uranium oxide powder, and, as a consequence, a significant local increase of the external dose characteristics of the RTG. A complex of organizational and technical measures, including all necessary measures for safety, localization of the emergency and RTG removal from the place of operation, were implemented. The costs were significant.

Secondly, there was a case of the disappearance of two RTGs of one of the coastal navigation systems on the Northern Sea Route in the area of the Laptev Sea, which the experts of the operating organization connected with thermokarstic processes in the coastal zone. The objects sank into the ground, as a result of which there was a landslide of coastal ground with gully formation. It is believed that at the bottom of this gully, under a layer of liquid soil, there are the two RTGs with the rest of the equipment. This situation may be aggravated by the fact that the heat generating capability of the RTGs can promote further sinking through the locally thawing permafrost, which will seriously complicate the search for the objects.

The final stage of the life cycle of the RHS-90s used in the RTGs (RPIs) is burial. The technology for RHS-90 burial has been developed and is carried out at the Mayak facilities. During 2001 and 2002, VNIITFA carried out the recycling of 100 RTGs and RPIs of various types. Up to the present time, Mayak has carried out burial of 100 RHS-90s from RTGs (RPIs) with a total ^{90}Sr activity of about 2.3 MCi.

The problem of RTG (RPI) recycling also raises the question of recycling of the depleted uranium used in a number of RTGs (RPIs) as radiation shielding blocks. Certainly this problem should be considered in combination with the recycling of the depleted uranium used as biological shielding in other products.

Thus for the approximately 1000 ^{90}Sr RTGs still in operation, the process of their safe removal from operation at the end of their service life for recycling and final burial has been worked out in detail organizationally, technically and technologically, but is hampered by the lack of the necessary financial resources under the economic conditions now existing in the Russian Federation. This circumstance is fraught with serious consequences, in view of the possibility of unauthorized actions affecting the integrity and safety of sources of high potential danger.

TABLE I. TYPES AND QUANTITIES OF ^{90}Sr RTGs IN THE RUSSIAN FEDERATION AND IN THE FORMER REPUBLICS OF THE USSR

Type of RTG	Activity at time of production (kCi)	Russian Federation		Former Soviet republics
		In operation	At temporary storage locations	
IEU-1	330	27	5	1
IEU-2	89	82	2	—
IEU-2M	100	23	—	—
IEU-1M	471	1	—	—
Beta	35	542	150	25
Gong	45	37	—	—
Gorn	168	67	9	—
Efir	105	38	2	—
Grab	270	—	1	—
REU-2	276	8	—	—
Pingvin	10	4	—	—
Sum, items		829	169	26
Total, items		998		26
Total activity at time of production (kCi)		57 108	9 070	1 205

3. RADIATION TECHNOLOGY EQUIPMENT WITH USE OF RADIOACTIVE SOURCES

The Russian Federation and countries of the former Soviet Union possess more than 250 γ irradiators of various types (Table I). Gamma irradiators mostly use sources based on ^{60}Co and ^{137}Cs. There is a large variety of γ irradiators, from small laboratory types to large industrial complexes. For example, laboratory systems for microbiological and biochemical investigations have a mass of 800 kg and contain 24 ^{137}Cs sources with a total activity of 2900 Ci.

The PXM-γ-30 and Investigator γ irradiators use ^{60}Co sources with a total activity of up to 30 000 Ci each.

Industrial plants contain some hundreds of ^{60}Co sources, each with an activity of up to 1200 Ci.

At present, more than 40 γ irradiators are to be taken out of operation, and the sources are to be unloaded and stored. Meanwhile, the total number of sources which should as a matter of urgency be removed and stored is more than 5000 for the various spent ^{60}Co ionizing sources and about 1000 for ^{137}Cs. The problem of ^{137}Cs source removal is a complicated one owing to the γ irradiator design, as further decommissioning was not foreseen.

DISCUSSION

A. HUSEYNOV (Azerbaijan): We have found two RTGs in Azerbaijan. One was sent back to the Russian Federation, to the manufacturer, and the other one, with an activity of 53 000 Ci, is in temporary storage. How many Beta type RTGs were shipped to Azerbaijan?

N.R. KUZELEV (Russian Federation): According to the information available to VNIITFA, which we have passed on to the IAEA, there is one such RTG in Azerbaijan.

A. HUSEYNOV (Azerbaijan): Would the Russian Federation take back, free of charge, the ^{90}Sr sources of RTGs discovered in Azerbaijan?

N.R. KUZELEV (Russian Federation): That is a legal matter for intergovernmental discussion. On the technical side, Minatom is conducting a source disposal programme, beginning with investigations of the condition of RTGs and the sources extracted from them.

K. GRYSHCHENKO (Ukraine): Could you say more about the Kandalaksha incident mentioned by you in your presentation?

N.R. KUZELEV (Russian Federation): The personnel who detected and located the RTGs in question were not overexposed, but during the dismantling of the RTGs four persons received rather high doses as a result of taking unauthorized actions.

K. GRYSHCHENKO (Ukraine): Is the Mayak enterprise prepared to make the technology developed by it for the disposal of RTGs available to other countries which have RTGs?

N.R. KUZELEV (Russian Federation): That is the first time I have been asked that question, which would have to be discussed with Minatom and with VNIITFA and the Mayak enterprise.

Seon Bin KIM (Republic of Korea): What is being done to preserve information about RTGs?

N.R. KUZELEV (Russian Federation): Unfortunately, many documents of the manufacturing enterprise — Baltiyets, in Estonia — have been lost. During the past five years, we have established a databank covering the Russian Federation and other countries of the Commonwealth of Independent States, and that databank has been provided to the IAEA. We are now carrying out investigations to determine the condition of as many RTGs as possible and then to refine the data in the databank.

P. ZIMMERMAN (United States of America): The Government of Norway has reported that the Russian Federation has 136 RTGs powering lighthouses between the Norwegian–Russian frontier and Murmansk, and the IAEA has indicated that there are some 600 RTG powered lighthouses along the Arctic coast of the Russian Federation. Apparently Norway has replaced five of the 136 RTGs by power sources based on solar technology. When and how will the Russian Federation replace the remaining RTGs, and how will it in the meantime prevent them from being stolen, breached, misappropriated or orphaned?

N.R. KUZELEV (Russian Federation): Along the Arctic coast of the Russian Federation and on various offshore islands there are about 500 RTGs, and they constitute a major cause for concern. For example, their operating temperature is 70°C, so they may well melt the underlying ice and disappear.

A.J. GONZÁLEZ (IAEA): There is a lot of uncertainty about the numbers of RTGs in different countries. The IAEA has indeed received information about RTGs, but I believe it relates only to RTGs which were supplied through Minatom and that there were other organizations in the former Soviet Union also supplying RTGs.

E. GIL LÓPEZ (Spain): It would seem that RTGs do not present unacceptable risks if they are under appropriate control. Are there any which are operating but not under appropriate control involving periodic inspections?

N.R. KUZELEV (Russian Federation): The organizations in the Russian Federation now responsible for regulatory activities have assumed control over all the RTGs referred to in my presentation. Some of these, however, are located in remote areas and are not protected. Unfortunately, that was not taken into account when they were designed, 30 years ago.

V. KOSENKO (Ukraine): We in Ukraine have had very good experience working with VNIITFA. What kinds of failure do you expect to occur when an RTG has been in service for 40 years?

N.R. KUZELEV (Russian Federation): The design service lifetime was ten years, but in the light of our experience with about 300 RTGs we now consider a service lifetime of 25–30 years to be quite realistic. We have not had a single case of source damage leading to an escape of radioactive material during such periods of operation, and the prognosis for a 40 year service lifetime is positive given normal operating conditions.

RTG cavities, including cavities with depleted uranium, may cease to be airtight if the devices are dismantled, struck or subjected to other unauthorized actions.

FINAL AND SECURE DISPOSAL OF RADIOACTIVE SOURCES: THE SITUATION IN THE EUROPEAN UNION

D.M. TAYLOR[1]
Directorate-General for Energy and Transport,
European Commission,
Brussels
E-mail: derek.taylor@cec.eu.int

Abstract

Sealed sources are used for a wide variety of purposes in the European Union and its neighbouring countries. The European Commission has studied the management of these sources for several years and has produced a number of reports covering the Member States, ten of the Candidate Countries and the Russian Federation. While the management of the sealed sources is now carried out in such a way as to ensure an adequate level of safety in most of the countries studied, the absence of dedicated centralized storage facilities means that many sources are still held at users' premises. In such cases the levels of both safety and security are reduced. There is an absence of proper disposal facilities for radioactive sources, especially the high activity sources, in most of the countries. Without such facilities, the safe and secure long term management of the sources cannot be fully guaranteed. New proposed legislation by the European Commission should improve the control and management of high activity sources within the European Union and also bring about the siting and construction of disposal sites. In the meantime, the establishment of improved centralized storage and disposal facilities could greatly benefit from increased international co-operation.

1. INTRODUCTION

All Member States of the European Union (EU) have been using sealed sources for many decades. The European Commission has been studying the issue of the radioactive sources used in industry, medicine and research and their management, including disposal, both inside the EU and in neighbouring countries, for several years.

[1] The views expressed in this paper are those of the author and may not necessarily reflect those of the European Commission.

2. SITUATION IN THE EUROPEAN UNION

Within the EU, the Commission has carried out a number of studies over the last five or six years concerning these sealed sources. Two studies in particular looked at the management of all types of sources. Both studies resulted in reports that have been published.

The first report dedicated to the subject — Management of Spent Radiation Sources in the European Union: Quantities, Storage, Recycling and Disposal — was published in 1996 (EUR 16960) [1]. It examined the management of spent sealed sources in the EU. It identified the quantities of sealed sources entering the European markets annually and considered how Member States currently regulate these sources. In particular, the report examined the waste management systems currently applied to spent sealed sources and investigated the risks associated with types of sources and disposal practices, and identified an appropriate waste management system based on the risks associated with sources. It concluded with a number of recommendations for further consideration. The report also suggested how the waste management systems across Europe could be improved and concluded that a multi-tier approach determined by the risk presented by a source throughout its life would be appropriate.

The risk assessment part of the study divided the sources into three categories depending on the risks they presented. In summary, these were:

— Low risk: ^{241}Am smoke detectors; ^{63}Ni β sources; ^{210}Po antistatic bars.
— Medium risk: ^{241}Am low energy γ sources; ^{226}Ra; ^{85}Kr β gauging sources; ^{137}Cs < 0.4 TBq.
— High risk: ^{60}Co LSA[2]; ^{137}Cs > 0.4 TBq; ^{192}Ir radiography sources.

However, it was also noted that both ^{241}Am and ^{226}Ra would be treated as high risk sources if the risks presented by the sources during their lifetime were considered.

The report examined the different management options, but insisted strongly on the fact that any preferred management option for the different types of sources depended on the availability of a long term disposal route. Without such a route it was hard to see how it would be possible to implement the recommended management option or options. In addition, the report concluded that there was no clear policy in the EU on who should pay for the disposal of

[2] Low specific activity (for ^{60}Co < 150 Ci/g) (1 Ci = 37 GBq).

spent sealed sources, nor was there a clear policy on where disposal sites should be situated — in the supplier country or the country of the beneficiary.

Finally, the report recommended that "the lack of disposal routes for a number of years needs to be addressed. Consideration should be given to the building of interim stores where none exist or those that do exist have little extra capacity".

The more recent report — Management and Disposal of Disused Sealed Radioactive Sources in the European Union — was published in 2000 (EUR 18186) [2]. This formed the technical basis for the forthcoming Euratom Directive on the subject. It specifically noted that while most Member States have laid down a regulatory framework to control sealed sources, there are still a number of uncertainties concerning management of historical ^{226}Ra α sources and concerning the possibility of retrieving non-registered sources, which may both represent high radiological risks for the population. In addition, management schemes and practices currently implemented in Member States may be somewhat conflicting and create problems for storage and disposal.

The general aim of this latter study was to propose improved management schemes for disused sealed radioactive sources in the EU, with a view to approximating policies of the Member States in this particular area.

The work covered the following activities:

— Review of the different regulatory frameworks laid down in each of the Member States.
— Analysis of the practices employed for the management of sealed sources throughout the EU, with a view to identifying possible gaps and contradictions. Particular attention has been paid to the management of historical ^{226}Ra sources.
— Generating proposals on how to retrieve non-registered disused sealed sources.
— Making recommendations for an improved management system at the European level with a view to developing EU policy actions in this area.

Much of the information contained in this study was obtained during face-to-face discussions with representatives of regulators, source users, original equipment manufacturers, distributors, source manufacturers and waste management organizations. Respondents from 59 organizations were interviewed during the study. Information was obtained from these respondents on the sealed source market in their Member State, the legislation and the way it is applied in practice, options for disposal of sealed sources and information on sources lost from regulatory control.

Although few respondents were able to provide full and accurate data on the numbers of sources sold, in use or sent for storage/disposal, it has still been possible to estimate these numbers. Of approximately 500 000 sources of relevance to this study supplied to current EU Member States over the past 50 years, approximately 110 000 remain in use. Most of the remainder have been sent to central interim stores, returned to manufacturers or disposed of.

The sources at greatest risk of being lost from regulatory control are disused sources held in local storage at the users' premises. It is estimated that there are about 30 000 sources stored in this way throughout the EU.

All Member States operate regulatory systems which require each user of sealed sources to hold a licence. In principle, there are many similarities between these systems. In practice, however, there are also many differences. In some cases, most regulatory attention is paid to assessing the competence of the prospective user before issuing a licence, and thereafter the amount of attention is limited. In other cases, regulatory control is applied throughout the source life cycle, with particular attention being paid to approval of individual source transfers. The regulatory structures also vary considerably. In States with small sealed source markets, a single regulator is responsible for all aspects of the use and disposal of sealed sources. In larger States there may be multiple regulators sharing responsibilities on a regional or functional basis.

Despite these differences, there is no evidence for any link between the regulatory system and the number of sources lost from regulatory control. All regulators were of the opinion that their current regulatory system was adequate. Other respondents broadly supported this opinion. However, respondents in most States identified some areas for improvement.

In 12 of the 15 Member States, there are regional or central interim stores capable of receiving most types of disused sources. These are operated by a variety of State owned bodies and commercial organizations. In the three remaining Member States (Greece, Ireland and Luxembourg), there is no central store, so disused sources are held in the users' premises. Regulators in these States are aware of the inventories and of the storage conditions. They have also made arrangements where possible for the disposal of these backlogs of sources. Pressure is applied in these States, through licensing conditions, to agree a disposal route before new sources are purchased.

Two Member States have disposal routes for a wide range of sources (Finland and Germany). A further three Member States have low level waste disposal routes capable of receiving small numbers of low activity sources (e.g. short lived isotopes). The remaining Member States have no disposal routes except where sources can be decay stored until the activity is below exemption levels. The return of sources to the manufacturer is encouraged in many States.

There is no consensus on the appropriate methods of treatment and conditioning of sources held in central interim storage. In most cases, the methods used are determined to a large extent by the available facilities, which may have been built to deal principally with other types of waste. However, segregation of sources from other wastes is normal above certain activity levels and on the basis of dose rate. In some cases, segregation by isotope or half-life is practised.

The report concluded that management schemes for disused sealed sources need to address the regulation of the use of sources as well as disposal practices and that there may be specific areas in which the development of common regulation may be appropriate. The report stressed that attention should be paid to the control of disused sources and sources of high activity.

The key recommendations of the study were that:

— Specific categories of source, which if involved in an incident may lead to unacceptable consequences, should be identified.
— Regulators in each Member State should be able to identify and locate all such sources under their control.
— Common objectives should be agreed for the regulatory management and disposal of disused sealed sources. These objectives should be implemented in a flexible way, through a Common Code of Practice.

A number of other specific recommendations were made for consideration both at EU level and by individual Member States. These recommendations could result in improvements to regulatory control of sources or to disposal arrangements.

The report provides excellent summaries on a Member State by Member State basis of the management systems in use. Copies of the report can be downloaded from the Commission’s web site http://europa.eu.int/comm/energy/nuclear/reports.htm (under the heading “radioactive waste management” — look for EUR 18186 [2]).

3. CANDIDATE COUNTRIES

The Commission has funded two important studies (1999–2002) of the situation regarding management of spent sealed radioactive sources in the ten Candidate Countries of Central and Eastern Europe. The reports of these two studies, EUR 19842 [3] and EUR 20654 [4], are available online via the above mentioned web page.

Until the end of the Soviet era, end of life management in most of the Candidate Countries followed Soviet practice. All institutional waste, including spent sealed radioactive sources, was routinely disposed of at RADON-style (surface vault) repositories, with spent sealed radioactive sources often disposed of in disposal tubes or gamma wells (about 5–6 m in depth), but also in the main vaults with the other waste forms. In both cases this could be with or without grouting (cement or concrete). Thousands of sources have already been disposed of in the Candidate Countries, many of them without conditioning.

The past disposal practices have since been reviewed in the light of more modern regulations and guidance (e.g. ICRP 81, recommendations of the IAEA, the Joint Convention and EU 'acquis'). Some disposal of spent sealed radioactive sources is still taking place, but only for sources with short (<30 a) half-lives. In some countries, longer lived sources are being stored temporarily in the existing facilities pending the availability of a suitable (i.e. deep) disposal route. Increasingly, purchase contracts for new sources require the re-export of the spent source back to the country of manufacture. At least one country is imposing a tax on the import of sources to help fund the national radioactive waste management strategy.

All existing facilities have been or are being subjected to revised safety assessments (often with assistance through the PHARE programme or the IAEA) to establish whether remedial measures are required. This is principally to counter the human intrusion scenario after the period during which institutional controls can be guaranteed. However, an accurate re-evaluation is possible only if there is a reliable inventory of disposed sources, and unfortunately this is often not the case (especially if the sites were used for disposal of military waste). It may therefore be necessary to retrieve these sources from such facilities, recondition them and either dispose of them elsewhere or store them pending the availability of a suitable disposal site.

The first of the two studies (EUR 19842 [3]) covered the Czech Republic, Estonia, Hungary, Poland and Slovenia. The report reviewed in detail the situation regarding sealed sources in these countries and made specific recommendations concerning each country. It also made a number of generic recommendations, some of which are briefly summarized below.

The report noted that the IAEA had recently revised its recommendations for the handling, conditioning and storage of spent sealed radioactive sources. The international consensus was that high activity and long lived sources required conditioning followed by interim storage. These sources, depending on their activity and half-life, would then need to be disposed of in either a near surface or a deep geological repository. It was not judged appropriate to store them in an unconditioned form. Among the countries covered by the study, only the Czech Republic was actively addressing the conditioning of sources in a manner consistent with IAEA recommendations. As regards storage prior to conditioning, there were some shortcomings. For instance, storage/disposal practice for some sources in Poland, and previous practices in Estonia and Hungary, did not fulfil the IAEA recommendations.

Poland, for example, had disposed of over 20 000 sources in the Rozan repository at the time of the report. Disposal here normally is into one of 16 concrete chambers about 5–10 m below the surface, by dropping the sources through access tubes (0.2–0.5 m diameter). In Estonia, at Tammiku, over 18 000 sources have been disposed of, mainly in a RADON-type borehole facility (see Section 4 for a description of the method). In addition, it is possible that some high activity sources have been embedded in the concrete grout used to in-fill the reactor compartments at Paldiski. Hungary had disposed of over 7000 sources at the time of the report. The disposal has been into 6 m deep stainless steel lined wells located in concrete. The diameter is generally small (40–200 mm). In the past, the sources were grouted in position, but they are now emplaced loose to allow for future retrieval.

Although each of the countries involved in this study has carried out some level of safety assessment of its storage and disposal facilities, the extent to which post-closure safety has been addressed appears to be very limited, on the basis of the information provided.

Although international Basic Safety Standards lay down limits from which clearance levels may be derived, the detection capability of typical fix-installed monitoring equipment does not meet these limits in the case of sealed sources in scrap, especially when these are shielded.

The second of the two studies [4] covered Bulgaria, Latvia, Lithuania, Romania and Slovakia. Again this report included country specific analyses, and both country specific and generic recommendations.

This study estimated that there were in excess of 10 000 spent sealed sources currently stored at the users' premises in the five countries. This represented approximately 18% of the sources in use. Noting that safety and security at users' premises are generally lower than at central storage facilities, the report suggests a number of incentives that could be introduced to reduce the number of sources presently in that situation. The report recommends that, in the light of increased international terrorist activities, this reduction should be given a high priority.

The report notes that in the past all of the countries covered have carried out near surface disposal which did not comply with existing IAEA recommendations. While the current operations aim to be consistent with IAEA recommendations for on-site storage, funding limitations do create some problems. In addition, only Romania has a near surface disposal facility which accepts sources, though it is not clear whether the disposal in this repository of long lived sources is in accordance with IAEA recommendations.

Finally, although each of the countries has carried out some level of safety assessment of its storage and/or disposal facilities, the extent to which post-closure safety has been addressed appears to be very limited.

Nonetheless, the two reports conclude that in most Candidate Countries the present day management of spent sealed radioactive sources, i.e. regulatory control, registration, services for collection, etc., and practice in general, is broadly equivalent to that in EU Member States. The principal problems are associated with past practice.

4. RUSSIAN FEDERATION

As a result of past and present civil nuclear activities (medicine, industry, research, etc.), about 2×10^6 Ci of spent sealed sources have accumulated in the 16 Russian RADON facilities. Various manufacturers, e.g. Mayak-Chelyabinsk, NIAR-Dimitrovgrad and FEI-Obninsk, are involved in the large scale production of sealed radioactive sources.

In view of the importance of the radiological risks associated with the actual management of spent sealed radioactive sources in the Russian Federation, especially when these sources are not subject to any form of regulatory control (the 'non-registered' sources), a further Commission funded study was carried out in 1997–1998 to examine the regulations laid down by the Russian authorities as well as the various management practices used to improve the safety level at a reasonable cost.

The study provided a description and an analysis of the situation in the Russian Federation regarding the management of sealed radioactive sources from fabrication to final waste disposal. The report on the study, EUR 18191 [5], was published in 1999. It has established the basis for a comparison between the situation and practice in the Russian Federation and those existing in the EU, with the purpose of identifying possible improvements which could become the subject of collaboration projects.

Of particular interest in the report is the section on the RADON centres. In this section there is a description of the disposal methods for sealed sources, in particular the different types of 'borehole repositories'. These shallow holes, typically between 4 and 8 m deep and about 1 m in diameter, usually contain a cylindrical stainless steel vessel (0.4 m diameter × 1.5 m height) into which the sources are introduced by a stainless steel, spiral shaped loading channel (diameter of around 0.1 m). The holes may or may not be concrete lined or filled. The loading channel is generally capped by a stainless steel lid and the hole by a concrete cap. Some sources were also embedded in a metal (lead) matrix. The report contains details (numbers and activities) of the sources disposed of at the different RADON centres in the period to 1997.

5. PROPOSED NEW EURATOM DIRECTIVE ON THE MANAGEMENT OF HIGH ACTIVITY SOURCES

The Euratom Treaty requires that uniform safety standards be established to protect the health of workers and the general public against the dangers of ionizing radiation. The first Basic Safety Standards (BSS) were adopted in 1959 and have since then been modified on several occasions. The most recent modifications were made in 1996 (Directive 96/29/Euratom [6]). Article 4(1)(e) of the BSS Directive requires prior authorization for, amongst other practices, the use of radioactive sources for industrial radiography, processing of products, research or the exposure of persons for medical treatment.

In 1999, the European Council concluded that there was a need for the EU to develop common views to address the problems related to radioactive scrap metals and proper management of spent radioactive sealed sources (2190th Council meeting, Luxembourg, 14–15 June 1999[3]).

The Council Resolution encouraged Member States to ensure the establishment and the implementation of arrangements to facilitate the management of contaminated materials constituting radioactive sources discovered in the recycling loop and invited the Commission to promote and facilitate homogeneity between the different national systems.

The BSS Directive sets out a number of provisions that, properly applied, would prevent the risks connected with the manufacture, use and disposal of high activity sealed sources. However, with respect to potentially highly dangerous sources, the European Commission felt that additional Community provisions were necessary to further reduce the likelihood of accidents involving such sources. The Commission therefore decided that the BSS Directive needed to be supplemented by a specific legal instrument to strengthen the control by the competent national authorities on the sealed sources posing the greatest risk.

The dramatic events of September 2001 increased public concern and highlighted the need for a strict control on radioactive sources.

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[3] Council Resolution on the Establishment of National Systems of Surveillance and Control of the Presence of Radioactive Materials in the Recycling of Metallic Materials in the Member States, 2002/C 119/05.

The objective of the new legislative proposal — a Council Directive — is to prevent exposure to ionizing radiation arising from inadequate control of high activity sources. It should harmonize controls in place in the Member States by setting out specific requirements ensuring that each source is kept under control.

A key element is the definition of "high activity source". This is defined as a "sealed source containing a radionuclide whose activity at the time of fabrication or at the first placing on the market is equal to or exceeds the relevant activity level specified in Annex 1". Annex 1 of the Directive is included as the Annex to this paper. The values are one hundredth of the activity limits applicable for the regulations on the safe transport of radioactive materials issued by the IAEA and above which transport must take place in packages designed and tested to ensure containment of the radioactive substance in accident conditions.

The following are the main points of the proposal for a Council Directive on the Control of High Activity Radioactive Sources, COM(2003) 18 Final [7].

— Scope (Article 1): Basically, the Directive would apply to sealed sources giving a dose rate in the order of more than 1 mSv/h at a distance of 1 m. The activity for the radionuclides most used in sealed sources is given in the Annex to the Directive (see above).

— Authorization (Article 3): The proposal requires prior authorization for any practice involving a high activity source. Before issuing an authorization, the competent authorities are required to ensure that arrangements have been made not only for the safe use of the source, but also for the proper management of the source when it becomes disused, which includes financial provisions.

— Records (Article 5): The Directive focuses the control on holders of sources, and not on the sources themselves. It provides for the use of a standard record sheet to be kept by holders of sources with information on the holder, on checks and tests performed on the source and on its transfer.

  Holders are required to notify a copy of the records at the time of opening of such records; at intervals of 12 months thereafter; at the closing of such records, when the holder no longer holds any sources; and whenever so requested by the competent authority.

— Common requirements for holders (Article 6): Holders of high activity sources are subject to the following obligations:

- To regularly verify that each high activity source is present at its place of use or of storage;

  - To ensure that each fixed and mobile high activity source is subject to adequate measures to prevent unauthorized access to or loss, theft, fire and unlawful use of the source;
  - To promptly notify to the competent authority loss, theft or unlawful use of a high activity source, and any event, including fire, that may have damaged the source;
  - To return or transfer each disused high activity source to a supplier or to a recognized installation unless otherwise agreed by the competent authority, without undue delay after termination of the use.
- Identification and marking (Article 7): The manufacturer is required to identify each high activity source by a unique number. Each source must be accompanied by additional specific written information.
- Orphan sources (Articles 9–11): The Directive proposes the following measures in connection with orphan sources:
  - Assignment of responsibilities for adequate preparedness in the event of interventions following the detection of an orphan source;
  - Identification of competent national bodies or points of contact where persons suspecting a possible orphan source can rapidly obtain advice and assistance;
  - Establishment of controls where orphan sources are most likely to appear, such as large metal scrapyards, major metal recycling installations or significant nodal transit points;
  - Organization of campaigns for recovering orphan sources, or sources in danger of becoming orphan;
  - Exchange of information between Member States and international organizations (Article 10);
  - Financial guarantee for intervention costs for orphan sources (Article 11).

The Commission expects that the Council will adopt the proposed Directive in the very near future. The Directive should then enter into force on the 20th day following its publication in the Official Journal of the European Communities.

6. PROPOSED NEW EUROPEAN UNION LEGISLATION ON RADIOACTIVE WASTE MANAGEMENT

It is clear that the safe and secure management of radioactive sources requires a disposal route. Even within the present Member States of the EU, the disposal options are very limited. Only two States have facilities that can accept a range of sources, and three others have disposal facilities for low activity sources. This situation could change in the relatively near future if a new proposal concerning radioactive waste is adopted by the European Council of Ministers [8].

While this proposal is not specifically targeted at sealed sources, their management would be covered by the proposal.

The objective of the proposed legislation is to bring about progress towards the safe long term management of spent nuclear fuel and radioactive waste. While the emphasis of the Directive is on high level waste — including spent nuclear fuel that is to be disposed of directly — it does cover all forms of radioactive waste and all spent nuclear fuel regardless of the management route followed (reprocessing, storage or direct disposal).

The Directive is very much inspired by the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. It includes a number of 'basic requirements' for safe management that will be quickly recognized by all who have studied the Convention. These measures can be considered as established international best practice in the field of spent nuclear fuel and radioactive waste management, and cover such aspects as public health, environmental protection, nuclear safety, financing and governance. Many of these measures are part of current policy in many Member States.

The Directive requires that each Member State establish a clearly defined programme for radioactive waste management covering all radioactive waste under its jurisdiction and covering all stages of management, including disposal. In particular, the programme is required to specify an approach to long term management and disposal with a definite timetable for each step of the process. Where there is no suitable alternative to disposal available, a small number of decision points must be included in the programme.

The Member States must report at regular intervals on their programmes, and the Commission, with the help of national experts, will review these reports and publish its own report on the situation regarding radioactive waste management in the EU.

Possibly the most controversial element of the proposed legislation relates to the three decision points that must be included in the programmes. They are:

— Authorization for development of appropriate disposal sites to be granted no later than 2008. In the case of geological disposal of high level and long lived waste, this authorization could be conditional upon a further period of detailed underground study.

— In the case of short lived low and intermediate level waste, if this is to be disposed of separately from high level and long lived waste, authorization for operation of the disposal facility to be granted no later than 2013.
— In the case of high level and long lived waste, to be disposed of in a geological repository, authorization for operation of the disposal facility to be granted no later than 2018.

The Directive strongly encourages progress on geological disposal, but it also advocates research, including into new technologies that would result in less radioactive waste.

The Directive allows the shipment of wastes to third countries as an alternative to disposal in a national repository. However, in order to avoid the risk of radioactive waste being sent to a country that could not safely manage it, there are strict conditions that would apply to such shipments. In particular, the shipments must be covered by firm contracts and only take place to a country with appropriate facilities that meet the accepted norms and standards of the country of origin and, in the case of special materials, under adequate safeguards.

Finally, the Directive aims to encourage more and better research on radioactive waste management. The Commission believes that the present level of research in the EU is inadequate. But, in addition to encouraging a higher level of research, the Commission wants to see the work better co-ordinated and plans to introduce proposals to achieve this in the coming months.

7. SUMMARY

While the management of radioactive sources in the EU and the Candidate Countries is generally adequate, there are a number of problems.

Within the present Member States alone, it is estimated that there are around 30 000 disused sources held on users' premises, though a large majority of these are unlikely to be high activity sources.

In three of the present Member States and in several of the Candidate Countries there are no central storage facilities for disused sources and a large number — also into the tens of thousands — are stored on users' premises.

Sources in storage on users' premises are unlikely to be as safe or as secure as those in central storage facilities. Increased international co-operation might be envisaged to set up more such facilities.

Finally, very few States have adequate, safe and secure disposal facilities for sources, in particular for high activity sources. Such disposal facilities are necessary if we are to guarantee the safe and secure long term management of sources.

The proposed new Council Directive on the control of high activity sealed radioactive sources should improve the situation in the future in the EU and also encourage the return of some of the orphan sources to within control.

The proposed new Council Directive on the management of spent fuel and radioactive waste should result in disposal routes for all types of sources within 10 to 15 years. This also could be an area for increased international co-operation in the interest of enhanced safety and security.

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[3] ANGUS, M.J., MORETON, A.D., WELLS, D.A., Management of Spent Sealed Radioactive Sources in Central and Eastern Europe, Rep. EUR 19842, European Commission (2001).

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[5] ALARDIN, J.-M., DECONINCK, J.-M., ERSHOV, V., Management of Sealed Radioactive Sources Produced and Sold in the Russian Federation, Rep. EUR 18191EN, European Commission (1999).

[6] Council Directive 96/29/Euratom of 13 May Laying down Basic Safety Standards for the Protection of the Health of Workers and the General Public against the Dangers Arising from Ionising Radiation (OJ L 159 of 29/06/1996).

[7] European Commission proposal for a Council Directive on the Control of High Activity Sealed Radioactive Sources, COM(2003) 18 Final.

[8] European Commission proposal for a Council Directive on the Management of Spent Nuclear Fuel and Radioactive Waste, COM(2003) 32.

Annex

ACTIVITY LEVELS

For radionuclides not listed in the table below, the relevant activity level is one hundredth of the corresponding A1 value given in the IAEA Regulations for the Safe Transport of Radioactive Material, 1996 Edition (Revised), Safety Standards Series No. TS-R-1 (ST-1, Rev.), IAEA, Vienna (2000).

Element (atomic number)	Radionuclide	Activity level (Bq)
Iron (26)	Fe-55	4×10^{11}
Cobalt (27)	Co-60	4×10^{9}
Selenium (34)	Se-75	3×10^{10}
Krypton (36)	Kr-85	1×10^{11}
Strontium (38)	Sr-90[a]	3×10^{9}
Palladium (40)	Pd-103[a]	4×10^{11}
Iodine (53)	I-125	2×10^{11}
Caesium (55)	Cs-137[a]	2×10^{10}
Promethium (61)	Pm-147	4×10^{11}
Gadolinium (64)	Gd-153	1×10^{11}
Thulium (69)	Tm-170	3×10^{10}
Iridium (77)	Ir-192	1×10^{10}
Thallium (81)	Tl-204	1×10^{11}
Radium (88)	Ra-226[b]	2×10^{9}
Plutonium (94)	Pu-238[a]	1×10^{11}
Americium (95)	Am-241[b]	1×10^{11}
Californium (98)	Cf-252	5×10^{8}

[a] The activity level includes contributions from daughter nuclides with half-lives of less than 10 d.

[b] includes neutron sources with beryllium.

DISCUSSION

M. ANTONOPOULOS-DOMIS (Greece): A reference was made by Mr. Taylor to Greece, and I should like to update his information regarding disused radioactive source management in my country.

To start with, Greece has a regulatory body with a complete record of all sources in the country, whether in use or disused.

Greece's main concern relates to the importation of disused sources in scrap. For that reason, at all relevant points of entry into the country — ports, border crossings and so on — there are radiation monitoring systems. Also, there are radiation monitoring portals at the entrances to steelworks.

About a year ago, we launched a programme for collecting disused sources from users' premises and taking them to the Demokritos National Centre for Scientific Research at the Institute of Nuclear Technology and Radiation Protection, of which I am the Director and where we have the know-how and the infrastructure necessary for dealing with them.

Most sources with relatively high activity have already been collected from users' premises, and we expect that the programme will be completed within a year from now.

At Demokritos we are erecting a facility for the interim storage of disused radioactive sources before they are exported pursuant to a 1990 law which requires the suppliers of sources imported into Greece to take them back after use. We have no intention of erecting a disposal or long term storage facility for disused radioactive sources.

D.M. TAYLOR (European Commission): I am pleased to hear about the progress made in Greece.

I should be interested to learn in due course what Greece intends to do with the sources which it imported before 1990 and which are not covered by re-export clauses.

H.D.K. CODÉE (Netherlands): What is the position of the European Commission regarding the shipment of disused sources to European Union countries from developing countries and other countries outside the European Union?

D.M. TAYLOR (European Commission): Basically, it is up to individual Member States whether or not to accept disused sources from abroad for management and ultimately for disposal. We would certainly not discourage them from doing so, especially if the acceptance of such sources increased general security and safety.

M. TOMAK (Turkey): What about the security aspects of the shipment of new radioactive sources from European Union countries to third countries?

D.M. TAYLOR (European Commission): I do not think we have ever had any particular security problems about the shipment of new radioactive sources to third countries.

The shipment of large quantities of spent fuel and high level waste is a different issue.

S.B. ELEGBA (Nigeria): In the 1980s, a tobacco company imported into Nigeria a number of ^{90}Sr sources for use as gauges. As there was no agreement with the parent company or with the supplier in Europe for the later return of the sources, these were ultimately deposited with a nuclear research institute in Nigeria.

We now have a regulatory body, and I was wondering whether, through the European Commission, it could negotiate an agreement for the return of the sources with the manufacturer or with the parent company I just mentioned.

D.M. TAYLOR (European Commission): We cannot force a Member State or an entity within a Member State to take back disused sources not covered by a take-back contract.However, we stand ready to help in situations like the one you have described. I shall look into the matter if you give me more information after this session.

SUMMARY OF TOPICAL SESSION 1

Mr. Croft explained that existing security arrangements for radioactive sources are inadequate and illustrated this with numerous examples of cases where sources had been lost from control and had caused injuries and fatalities. He advocated each country developing a national strategy for regaining control over orphan sources and for securing vulnerable sources. The IAEA documents and methodology provide guidance on how to do this. Mr. Croft also noted that disused sources were the biggest problem and that one third to one quarter of all sources are disused.

Mr. Paperiello discussed which sources were of greatest concern with respect to radiological dispersal devices. He presented the thinking behind the joint DOE/NRC study to identify the high risk sources and compared it with the IAEA's source categorization methodology. It was recognized that ideally there would be a harmonization of categorizations to ensure that there is consistent application worldwide, especially with regard to exports/imports. Only a small fraction of radioactive sources pose a significant risk. Categorization is the cornerstone of a large number of issues, but it needs to be simple and implementable within a national regulatory system.

Mr. Ulvsand, Mr. Fracas and Mr. Krishnamachari all addressed the issues of searching for and locating radioactive sources. It was concluded that it is possible with current technology and a sensible search strategy to find significant sources using a combination of both vehicle and airborne surveys. However, all sources are not always found, and further development of detector capabilities would be valuable.

Mr. Kuzelev addressed the issue of Soviet origin RTGs. Their design, use and distribution were outlined. He stated that they have a number of unique applications which cannot be achieved by any other means, especially in remote locations like the Arctic. Many sources were designed for a lifetime of 10 years, but have now been operating for 25 years and are likely to be able to run for another 15 years. A programme of activity is under way to inspect and recertify all RTGs in use and to dispose of those which are disused. There was some significant discussion regarding the number of RTGs that may have been distributed during the Soviet era.

Mr. Taylor discussed the fact that despite the title of his paper, there is in reality very little disposal of radioactive sources within the EU. Very few countries have the necessary disposal sites or programmes in place, although the EU has a number of legal measures under way to eventually solve the problem of safe and secure disposal.

STRENGTHENING LONG TERM CONTROL OVER RADIOACTIVE SOURCES

(Topical Session 2)

Chairpersons

R.A. Meserve
United States of America

A.D. Wrixon
IAEA

STRENGTHENING LONG TERM CONTROL OVER RADIOACTIVE SOURCES

R.A. Meserve
Chairman,
United States Nuclear Regulatory Commission,
Washington, D.C.,
United States of America

Introduction

I am pleased to open this Topical Session on Strengthening Long Term Control over Radioactive Sources. I will try to set the stage for the series of presentations that are scheduled for this session.

The traditional focus of the regulation of radioactive sources is the protection of workers and the public from the misuse of sources and from accidents. Security measures were also a concern, but with the principal aim of preventing petty theft or accidental loss. The events of September 11, 2001, have changed the way in which we must think about sources. Our perspective must now encompass the possible malevolent use of sources as weapons of terror. And, as a result, past practices need to be modified to reflect new circumstances.

Our concern, of course, is that a high risk radioactive source might be married with conventional explosives and used in a radiological dispersal device (RDD). Although our analyses show that such a device is not an effective means to cause large numbers of fatalities — RDDs are not part of the military arsenal of any country for the simple reason that they are not good weapons — devices utilizing high risk sources might nonetheless meet a terrorist's objectives. The use of such a device could cause panic, could seriously disrupt normal activities in the affected area, and might cause serious economic harm because of the possible need for evacuation and expensive decontamination efforts. Therefore means must be found to protect the public from the use of high risk radioactive sources in an RDD.

The task may appear daunting at first because of the widespread use of radioactive sources throughout the world. Such sources are in common use in medical practice, in academic research and in numerous industrial applications, such as γ irradiation, radiography, gauging, gas chromatography and well logging. By way of example, there are about 150 000 licensees for radioactive materials in the USA, and about 2 million sources are in use. Moreover, domestic and international commerce in these sources is extensive, and existing controls on imports and exports, particularly for sources of low to moderate risk, are minimal.

Compounding the problem is the fact that there also is a general lack of effective domestic controls on even high risk radioactive sources. The IAEA has noted that more than 100 countries lack effective control over radiation sources because most do not have the required infrastructure.[1] The IAEA's Model Project is intended to aid Member States in developing the necessary infrastructure, but progress has been slow. And even in those countries that do have a regulatory infrastructure, authorities have not always been able to devote resources to the control of high risk radiation sources. Certainly the IAEA's long standing efforts to improve the regulation of sources throughout the globe deserve continuing support and attention independent of the new challenges presented by RDDs.

The focus of this conference, however, is not the general need for improved regulation, but rather the narrower objective of preventing the malevolent use of radioactive sources by terrorists. Fortunately the challenge in dealing with RDDs is simpler in some respects than the general need for comprehensive regulatory reform. Only a very small fraction of the sources now in commercial use are of value as terrorist weapons because most commercial sources have too little activity or too short a half-life, or otherwise are not suitable for terrorist use. Moreover, many large sources may be difficult to use in an explosive device because even a suicidal terrorist might receive a lethal dose of radiation, absent the use of bulky shielding and specialized equipment, before an RDD employing the source could be deployed. Thus in dealing with the RDD problem we can focus our efforts by establishing stringent controls on the small fraction of sources that present a high risk if used by a terrorist.

The US Nuclear Regulatory Commission (NRC), like, I suspect, our counterparts in other countries, has found that modification of our regulatory programme to account for the terrorist threat is necessary. Although our work on this problem is still under way, let me briefly outline some of the components that we believe are elements of an effective regulatory programme to counteract the RDD threat. The aim is a programme that achieves an appropriate balance of safety, security, public benefit and economic feasibility.

1. Categorization. The starting point, of course, must be the definition of those high risk sources that require enhanced protection. Categorization of sources was the focus of Topical Session 1, so I will not dwell on this topic. I

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[1] GONZÁLEZ, A.J., Timely action: Strengthening the safety of radiation sources and the security of radioactive materials, Int. At. Energy Agency Bull. **41** 3 (1999) 2.

must note, however, that categorization will be the cornerstone for the entire international system of controls for high risk sources, and that, as Mr. Paperiello has pointed out in his talk in Session 1, we must reach consensus. The USA stands prepared to discuss the methodology it has developed, and we will work with others to establish an appropriate categorization scheme.

2. Security measures. Strong domestic regulatory oversight to prevent ready access to high risk sources by terrorists must obviously be the heart of the system. Elements of the regulatory system should include: verification of the legitimacy of applicants for licences; requirements governing the security of high risk sources while in transit, in storage or in use; controls on access to prevent diversion by an insider; requirements for tracking and inventorying high risk sources to ensure that no source has been lost or stolen; more frequent inspections to verify the adequacy of the regulatory controls; and measures to ensure safe disposal. In short, we must strive to establish cradle to grave security for the relevant sources. Although the USA had some of these elements in place before September 11, we see the need for further changes. In the interim, we have instructed licensees to apply additional physical security measures that limit access to high risk sources and to provide additional barriers to prevent possible theft or diversion.

3. Imports/exports. Because of the international commerce in radioactive sources, each country has an interest in ensuring a harmonious international system for exports and imports of high risk sources. Moreover, there is a corresponding need to enhance border and port security to seek to interdict the illicit transport of high risk sources.

4. Disposal. Proper disposal of sources is a constant quandary because disposal facilities are limited and, in the past, there was little incentive for licensees to dispose of unused lower risk, generally licensed sources properly. The NRC now requires all licensees to dispose of sources properly and will impose penalties for unauthorized disposal of at least three times the cost of proper disposal.

We also are examining options for providing additional disposal capacity. This is a challenge in the USA because there is no facility for disposal of those sources presenting the greatest risk, and as a result all such discarded sources must be stored.

5. Orphan sources. Ensuring options for disposal only addresses sources that are still under control. Many sources have been lost, abandoned or otherwise misplaced. Although only a tiny fraction of these sources are in the high risk category in the USA, orphan sources are a challenge that must be confronted around the world.

6. Emergency response. No regulatory system can be 100% effective. Therefore steps must be taken to ensure that proper emergency response procedures are in place to evaluate and respond to a terrorist event involving an RDD. Because any event involving an RDD is likely to cause significant concern, effective means to evaluate the potential consequences and disseminate accurate and timely information to the public are an essential element of any such planning.

Conclusion

In summary, radiation sources and devices containing radioactive materials provide important benefits to individuals and to society when they are properly designed, safely used and carefully secured. Effective national and international programmes are needed to ensure these characteristics. Activities related to development of the Code of Conduct and the Action Plan for the Safety and Security of Radioactive Sources are first steps. But more is yet to be done, particularly because the possible terrorist use of radioactive sources is a new element that was not a fundamental consideration in the establishment of existing regulatory programmes.

It is also important that we, as national leaders, rededicate ourselves to providing accurate, unbiased, timely and appropriate information to the public. A strong voice is vital in ensuring that the public is not inappropriately alarmed about the dangers associated with RDDs.

This session is intended to explore some of the attributes of an effective regulatory programme to deal with RDDs. I have given only a brief summary of some of the elements of such a programme. These elements, and no doubt others, will be pursued in greater depth by the speakers that follow.

Again, let me express my appreciation for the opportunity to be here today. We are working together on an important problem.

REVISED CODE OF CONDUCT ON THE SAFETY AND SECURITY OF RADIOACTIVE SOURCES

S. McINTOSH
Australian Nuclear Science and Technology
Organisation (ANSTO),
Menai, New South Wales,
Australia
E-mail: smi@ansto.gov.au

Abstract

The paper presents a brief history of the development of the Code of Conduct on the Safety and Security of Radioactive Sources, describing the current Code, the revision of the Code and the March 2003 draft revised Code, along with the next steps to be taken.

1. HISTORY

The first mention of an international undertaking in the area of the safety and security of radiation sources was made in the findings of the Conference on the Safety of Radiation Sources and Security of Radioactive Materials held in Dijon in 1998. These findings were reported to the IAEA General Conference later that year.

As a follow-up to the Dijon Conference, the IAEA Board of Governors requested the IAEA Secretariat to prepare an international Action Plan. It approved the international Action Plan for the Safety and Security of Radioactive Sources in September 1999. At the same time, it requested the Director General to initiate exploratory discussions relating to an international undertaking in the area of the safety and security of radiation sources, it being understood that the international undertaking should provide for a clear commitment by and attract the broad adherence of States. The Action Plan envisaged that the undertaking should address:

— Establishment of regulatory infrastructures;
— National arrangements for prompt reporting of missing sources;
— National systems for ensuring appropriate training of personnel;

— National arrangements for management and disposal of disused sources;
— Arrangements for response to the detection of orphan sources.

In the implementation of this part of the Action Plan, meetings of legal and technical experts were held in March and July 2000 under my chairmanship. Those meetings developed the Code of Conduct on the Safety and Security of Radioactive Sources. The September 2000 meeting of the Board of Governors requested the Director General to organize consultations on the application and implementation of the Code and make recommendations to the Board. The subsequent General Conference invited Member States to take note of the Code and to consider, as appropriate, means of ensuring its wide application.

2. THE CURRENT CODE

The Code:

— Applies only to sealed radioactive sources;
— Is addressed to States, not manufacturers, suppliers, etc.;
— Provides that, in the case of transboundary movement of a source, the main responsibility for safety lies with the importing State;
— Contains no agreement regarding obligations of exporting States;
— Is a non-binding document, there being no consensus within the Experts' Group that the Code should be binding in any way;
— Covers essential administrative matters.

The objective of the Code (paragraph 4) is "to achieve and maintain a high level of safety and security of radioactive sources through the development, harmonization and enforcement of national policies, laws and regulations and through the fostering of international co-operation." To achieve that objective, every State should:

— Establish an effective legislative and regulatory system, including a regulatory body. The system should, inter alia, place the prime responsibility for safety on the user, and minimize the likelihood of loss of control (paragraph 9). Paragraphs 13 and 14 of the Code provide details of the recommended content of such a system, whilst paragraphs 15–17 set out the recommended powers of the regulatory body.
— Ensure that appropriate facilities and services for radiation protection and safety are available, including those needed for searching for missing

sources and securing found sources, for intervening in the event of an accident or incident and for personal dosimetry and environmental monitoring (paragraph 10).
- Ensure that adequate arrangements are in place for appropriate training of staff of the regulatory body, customs officers, police and staff of other law enforcement agencies (paragraph 11).
- Encourage bodies or persons likely to encounter orphan sources during normal operations to implement monitoring to detect such sources (paragraph 12).

As noted above, a range of provisions of the Code are relevant to maintaining control over sources. Some of those provisions explicitly refer to the needs of ‘security’. At the time, the focus of the Experts’ Group was very much on incidents such as persons stealing shiny objects for scrap metal resale — as has occurred in Goiânia and a number of other places. The Group gave no consideration to the possible use of sources in radiological dispersal devices.

3. REVISION OF THE CODE

As noted earlier, the Board of Governors envisaged in September 2000 that the Code might be subject to revision. During 2002, the Secretariat sent a questionnaire to Member States, the content of which was partly influenced by the terrible events of September 2001. That questionnaire sought States’ views on possible revisions and enhancements to the Code, including those in relation to security. Following the receipt of States’ replies, the Secretariat convened a further Experts’ Meeting to Review the Code of Conduct in August 2002, again under my chairmanship. The draft revision of the Code agreed at that meeting included new provisions relating to:

- National registries,
- Export controls,
- Strengthened security requirements,
- Confidentiality of information.

The Revised Code in draft form was submitted to the Board of Governors in September 2002 for information. Following substantial work on the revision of the IAEA’s Categorization of Radioactive Sources, the Code was further revised in early March 2003.

4. THE MARCH 2003 DRAFT REVISED CODE

The objective of the draft revised Code has been expanded from the original objective. It now includes an explicit reference to the need to prevent unauthorized access or damage to, and loss, theft and unauthorized transfer of, radioactive sources, and to prevent the malevolent use of radioactive sources to cause harm to individuals, society or the environment.

Further, the scope of the draft revised Code is more explicit than that of the original. It focuses on sealed radioactive sources of Categories 1, 2 and 3 of the revised Categorization of Radioactive Sources — that is, sources which, if not managed safely and securely, could lead to the death or permanent injury of individuals in close proximity to the unshielded source. As with the 2000 Code, it continues to exclude nuclear materials (the protection of which is subject to a separate international regime) and radioactive sources within military or defence programmes (which are often not subject to the same sort of regulatory structure as sources within civilian programmes). The Code continues to provide guidance on legislation, regulations and the regulatory body, and now also provides guidance on import and export controls.

But it is with respect to the security of sources that the most significant enhancements have been made. Among the new or amended provisions are that:

— States should ensure that radioactive sources within their territory, or under their jurisdiction or control, are safely managed and securely protected during their useful lives and at the end of their useful lives.
— States should promote a security culture.
— States should establish an effective national legislative and regulatory system of control, recognizing that prime responsibility for the safe management of, and the security of, radioactive sources remains on the persons being granted the relevant authorizations.
— Designers, manufacturers, suppliers, users and those managing disused sources have responsibilities for the safety and security of radioactive sources.
— National legislation and regulations should include requirements relating to the verification of the safety and security of radioactive sources.
— Provision should be made for the safe management and secure protection of sources once they become disused.
— States should promptly notify incidents of loss of control or with potential transboundary effects to potentially affected States.

The Code also addresses consideration of the need for an assessment of the security of the source and/or the facility, in the light of the current national threat assessment; the importance of safe and secure management of disused sources; and the need for confidentiality of information relating to the security of sources.

5. NEXT STEPS

The March 2003 meeting resulted in broad agreement on the text, ad referendum to capitals. The Code was to be sent to all Member States for comment by 1 June. A further (and hopefully final) meeting of the Group was to be held on 14–18 July. The aim is for a finalized revised Code to be submitted to the IAEA Board and General Conference in September 2003.

The current Code is recommendatory only; it is not binding in international law. At the March meeting, and outside the Group, views have been expressed that the Code should be subject to some sort of undertaking by governments, in order to demonstrate their commitment to its principles and to create a level playing field for manufacturers and users of sources. At the meeting, Experts agreed to take the issue back to their governments for consideration. The chairman will prepare and circulate an options paper prior to the July meeting.

DISCUSSION

K.S. PRADEEP KUMAR (India): If a powerful radioactive source were smuggled from one country into another country, it could give rise to a radiological emergency in the latter country. How is such a possibility taken into account in the draft revised Code of Conduct on the Safety and Security of Radioactive Sources?

S. McINTOSH (Australia): The draft revised Code of Conduct goes beyond the Convention on Early Notification of a Nuclear Accident (the Early Notification Convention) in requiring notification of the loss of control over powerful radioactive sources, so that potentially affected States may step up their border monitoring and take other appropriate actions.

E. MARTELL (Canada): What new responsibilities would the draft revised Code of Conduct place on an exporting State?

S. McINTOSH (Australia): The exporting State would have to ensure that the recipient of the source was authorized by the regulatory body of the importing State to receive the source. Also, when deciding whether to authorize the export it would have to take into account the degree to which the importing

State is able to manage sources properly and manage them in a safe and secure manner.

M.G. ALBERT (France): My country welcomes the fact that the Code of Conduct is being revised, and especially that it is being strengthened with regard to security. It looks forward to a revised text being considered — and hopefully approved — by the IAEA Board of Governors and General Conference.

The first priority of the international community should then be to promote the widest possible application of the revised Code of Conduct, although we recognize that this will have to be a gradual process as many States will not be in a position to apply all provisions in the short term.

However, we feel that the international community needs to think beyond that first priority and prepare for a move towards international undertakings based on the revised Code of Conduct, in a form to be defined.

In particular, we feel that those States which are the main users and exporters of sources, and more advanced in terms of regulatory control, should have a special responsibility in preparing for that move. They should work together in identifying ways to initiate the move and consider entering into political commitments based on the revised Code of Conduct — commitments of a precise nature to be determined.

S. McINTOSH (Australia): I agree. In my view, those States which are the main users and exporters of radioactive sources should assume a leadership role as regards application of the revised Code of Conduct. Moreover, a co-ordinated approach to the terms and timing of undertakings would be welcome.

S.B. ELEGBA (Nigeria): What do you expect the nature of the undertakings to be?

S. McINTOSH (Australia): In my view, it is almost inevitable that the open ended group of technical and legal experts which produced the draft revised Code of Conduct will meet in July 2003, and this issue will probably be considered at the meeting. If it is, the open ended group may well make a recommendation to the IAEA's policy making organs (Board of Governors and General Conference). The final decision as to whether there should be an undertaking, its level and its form would have to be taken by the General Conference.

S.B. ELEGBA (Nigeria): How would the question of the responsibility of supplier companies vis-à-vis their host countries be handled?

S. McINTOSH (Australia): The draft revised Code of Conduct requires that the export of dangerous sources be subject to authorization. States committed to the revised Code of Conduct would be required not to authorize exports if supplier companies had not paid proper regard to its provisions.

E. GIL LÓPEZ (Spain): In Topical Session 1, Mr. Taylor spoke about a proposal for a European Council Directive on the control of high activity radioactive sources. Is there not a risk of inconsistencies between such a regional instrument and the revised Code of Conduct?

S. McINTOSH (Australia): This is not a problem unique to the regulation of radioactive sources; it exists also in connection with the regulation of nuclear facilities and nuclear materials.

In my view, it is up to States not to enter into incompatible commitments. During the work on revising the Code of Conduct, experts from Member States of the European Union have repeatedly referred to the envisaged Directive and voiced their concern that it and the revised Code of Conduct should be consistent.

SECURITY OF RADIOACTIVE SOURCES: INTERIM GUIDANCE FOR COMMENT

B. DODD, R. CAMERON, A. HAGEMANN
Department of Nuclear Safety and Security,
International Atomic Energy Agency,
Vienna
E-mail: b.dodd@iaea.org

Abstract

The paper is a brief summary of the material contained in IAEA-TECDOC-1355, Security of Radioactive Sources: Interim Guidance for Comment, covering the topics of threat assessment, Security Groups and performance objectives, and security based categorization.

1. INTRODUCTION

In previous IAEA publications, there have been only rather general security requirements for non-nuclear radioactive material. These requirements were primarily directed to such issues as unintentional exposure to radiation, negligence and inadvertent loss. However, it is clear that more guidance is needed not only to try and prevent further events involving orphan sources, but also to prevent the deliberate attempt to acquire radioactive sources for malevolent purposes.

This paper is a brief summary of material contained in IAEA-TECDOC-1355, Security of Radioactive Sources: Interim Guidance for Comment[1]. The purpose of the document is to assist Member States in deciding what security measures are needed for different sources. It is aimed at regulators, but it will also be of assistance to manufacturers, suppliers and users. With regard to the security of radioactive sources, it is recognized that there is a necessary balance between managing sources safely and securely, but still enabling their beneficial use. Thus the security level needs to be commensurate with the threat level and with the risk associated with unauthorized access to and acquisition of the source. Finally, it is noted that existing safety requirements may go a long way

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Security of Radioactive Sources: Interim Guidance for Comment, IAEA-TECDOC-1355, Vienna (2003).

towards meeting the security requirements for a particular source. A complete programme aimed at addressing the malevolent use of radioactive sources needs to consider a large range of issues, including: the appropriate design and manufacture of sources; the various means of acquisition of sources; the prevention of use of any sources acquired; and the mitigation of the impacts if sources are used malevolently. This paper covers only the processes to determine what level of security is required for sources throughout their life cycle, and the assignment of security measures to sources on the basis of graded performance requirements to deter, detect and, if necessary, appropriately respond to theft of radioactive material.

2. THREAT ASSESSMENT

The suggested approach to security of radioactive sources would involve a threat assessment that first characterizes the type of source, as well as its nature and application. Then an evaluation of the potential threat for a particular country or region can be made, on the basis of information from appropriate intelligence or security experts. When this is combined with an evaluation of the consequences of a successful attempt to acquire the source, a design basis threat can be determined. This then becomes the threat against which the specific source security should be designed and evaluated. A vulnerability analysis is then performed for that source against the defined threat, and if there is a need to reduce the risk of acquisition, the existing security measures can be optimized and necessary additional measures implemented.

Should the necessary information not be available to perform such a threat assessment or should it be deemed unnecessary, then one approach is to develop graded security measures based purely on the potential consequences of malevolent use. This alternative is discussed later in this paper.

3. SECURITY GROUPS AND PERFORMANCE OBJECTIVES

The level of the assessed risk will determine the security measures required to protect the source. The higher the risk, the more capability will be required from the security systems.

This level of capability can be expressed as performance objectives for the security system. While there are a wide range of possible security measures, they can be described by their capability to deter, to detect and to delay unauthorized access or acquisition.

In this section, four Security Groups are defined on the basis of these fundamental protection capabilities. They provide a systematic way of categorizing the graded performance objectives required to cover the range of security measures that might be needed, depending on the assessed risk. These are:

— *Security Group A:* Measures should be established to deter unauthorized access, and to detect unauthorized access and acquisition of the source in a timely manner. These measures should be such as to delay acquisition until response is possible.
— *Security Group B:* Measures should be established to deter unauthorized access, and to detect unauthorized access and acquisition of the source in a timely manner.
— *Security Group C:* Measures should be established to deter unauthorized access and verify the presence of the source at set intervals.
— *Security Group D:* Measures should be established to ensure safe use of the source and adequately protect it as an asset, verifying its presence at set intervals.

IAEA-TECDOC-1355 then provides some examples of how these performance objectives might be met by the use of a combination of administrative and technical measures. These security measures should be seen as an integrated concept of safety and security involving industrial safety arrangements, radiation protection measures and appropriate design to achieve the necessary level of protection against unauthorized acquisition of radioactive sources.

Some of these measures are summarized in Table I.

For example, to satisfy the performance requirements to protect a Group A source in storage, the source could be in a locked and fixed container or device, which is in a locked storage room that separates the container from unauthorized personnel and which is subject to continuous detection of intrusion attempts. There would be access control to the storage room as well as the ability to respond in a timely manner to detected attempts at unauthorized access. In a similar manner, the other Security Group requirements can be established.

4. SECURITY BASED ON CATEGORIZATION

Where the design basis threat assessment methodology is not practical, other ways of assigning sources to Security Groups could be used. These could, for example, be based on a generic assessment carried out in a particular

TABLE I. ADMINISTRATIVE AND TECHNICAL SECURITY MEASURES

<table>
<tr><th>Group A</th><th>Group B</th><th>Group C</th><th>Group D</th></tr>
<tr><td colspan="4">General administrative measures</td></tr>
<tr><td>Daily accounting</td><td>Weekly accounting</td><td>Semi-annual accounting</td><td>Annual accounting</td></tr>
<tr><td colspan="2">Access control to source location allowing timely detection of unauthorized access</td><td>Access control to source location</td><td rowspan="11">No specific provisions.
Routine measures to ensure safe use and protect source as an asset</td></tr>
<tr><td colspan="3">Deterrence provided by:</td></tr>
<tr><td>A. Two technical measures separating the source from unauthorized personnel</td><td>B. Two measures (one technical) separating the source from unauthorized personnel</td><td>C. One technical measure separating the source from unauthorized personnel</td></tr>
<tr><td colspan="2">Specific emergency response plan</td><td>Generic emergency response plan</td></tr>
<tr><td colspan="2">Background checks</td><td rowspan="7"></td></tr>
<tr><td colspan="2">Security plan</td></tr>
<tr><td colspan="2">Information security</td></tr>
<tr><td colspan="2">Upgrade of security for increased threat</td></tr>
<tr><td colspan="2">Timely detection provided by:</td></tr>
<tr><td>A. Remotely monitored intruder alarm</td><td>B. Local alarm</td></tr>
<tr><td>Timely response to an alarm</td><td></td></tr>
</table>

country or on the basis of the consequences of malevolent use. A default assignment based on an assumed threat from a determined group and the immediate health consequences of an uncontrolled source could also be used. Since the IAEA's Categorization of Radioactive Sources[2] is based on the

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Categorization of Radioactive Sources, IAEA-TECDOC-1344, Vienna (2003).

TABLE II. CATEGORIZATION OF SOURCES

Security Group	Source Category	Examples of practices
A	1	Radioisotope thermoelectric generators (RTGs) Irradiators Teletherapy Fixed multibeam teletherapy (γ knife)
B	2	Industrial radiography High/medium dose rate brachytherapy
	3	Fixed industrial gauges (e.g. level, dredger, conveyor) Well logging gauges
C	4	Low dose rate brachytherapy (except those below) Thickness/fill-level gauges Portable gauges (e.g. moisture/density) Bone densitometers Static eliminators
D	5	Low dose rate brachytherapy eye plaques and permanent implant sources X ray fluorescence devices Electron capture devices

potential deterministic health effects of uncontrolled sources, it may be used as a surrogate, as shown in Table II.

As an example, a fixed radiography installation would be in Security Group B and could meet the guidance by being used in a locked room with continuous surveillance of the source and access control to the room.

In all cases, the specific type and quality of the security measures (locks, detectors, etc.) should be based on the required ability to deter, detect or delay any attempt at unauthorized removal of the source.

5. FURTHER ISSUES

These security assessments impose additional responsibilities on regulators and users, and each country should establish a system to ensure that the appropriate assessments are carried out as part of the licensing process. IAEA-TECDOC-1355 provides guidance on these roles and responsibilities.

Pragmatically, it is recognized that it might not always be possible to achieve the specified performance objectives by technical measures, and hence additional administrative measures need to be rigorously maintained. This usually means personnel surveillance. Additional guidance is given within IAEA-TECDOC-1355 on security measures to apply when there are specific threats and for temporary storage, such as when an orphan source is recovered.

6. CONCLUSIONS

It is believed that the guidance issued for comment in IAEA-TECDOC-1355 provides a basis for the further enhancement of security of radioactive sources. It provides flexibility for the use of a threat assessment methodology if desired, but also allows for consideration of other ways of assigning security measures. It provides graduated performance objectives to allow for the different risks associated with radioactive sources, and gives realistic specific measures for types of sources, both in storage and in use. It attempts to balance safety, security and beneficial use. Comments on the document will be gratefully received by the IAEA (b.dodd@iaea.org).

DISCUSSION

K.E. DUFTSCHMID (Austria): Could Mr. Biro give us some information about the present extent of border monitoring in Romania?

L. BIRO (Romania): We have two portal monitors in place — one on the border with Moldova and one on the border with Bulgaria — and customs officers have been provided with handheld devices.

Under a programme run by the United States customs authorities, the needs of all Romania's border crossing points are to be assessed and then proposals made for meeting those needs.

S.V. NOVIKOV (Russian Federation): I should like to make three points. First, what is the attraction of radiological terrorism for terrorists? Not the physical damage that can be caused but the psychological destabilization of society based on an over-assessment of the radiological risk — on radiophobia. Hence, one way of preventing radiological terrorism is to combat radiophobia by educating the public.

Second, we are very good at measuring radiation, with methods sensitive enough to measure radiation levels five to eight orders of magnitude lower than the maximum permitted levels. When we detect traces of radioisotopes such as ^{131}I or ^{137}Cs at levels some seven orders of magnitude below the maximum permitted levels and discuss the fact in the mass media, that is not providing information to the public — it is information based terrorism.

Third, we live in an ocean of risks. The risks associated with different technologies are limited by various standards ranging over several orders of magnitude. Radiological risks are two to three orders of magnitude lower than other kinds of risk, and the standards are correspondingly more stringent. From the points of view of logic and economics, risks should be evened out, some standards being made more stringent and others less. As far as radiation safety standards are concerned, I feel that they are too stringent, and that this issue should be examined at a future conference like this one.

B. DODD (IAEA): I agree with what you said, especially about radiophobia and educating the public.

A. LABOUDI (Algeria): In my view, the regulations which apply to the export and import of radioactive sources will be circumvented by those who wish to engage in illicit trafficking.

R.A. MESERVE (USA): That is an important point. The controls on those who are law-abiding will not be sufficient to deal with the threat of radiological terrorism.

J.K. KAMANDE (Kenya): Like landmines, there are many radioactive sources ‘orphaned’ by the military. In my view, every State should be held responsible when its military orphans radioactive sources by abandoning them.

G. KING’ORIAH (Kenya): The expression ‘dirty bomb’ suggests that there are ‘clean’ bombs. In my view, our aim should be to eliminate all bombs.

R.A. MESERVE (USA): I am not sure whether those comments fall within the scope of this discussion.

As regards the expression ‘dirty bomb’, it is commonly used in the media to denote a radiological dispersal device (RDD), the impact of which would rely more on the panic which it might cause than on the explosive or radiological damage. Educating the public with regard to the nature of ionizing radiation is important for minimizing such panic, and ‘dirty bomb’ is perhaps an expression which the public can relate to more easily than ‘RDD’.

J. LOY (Australia): As a regulator, I agree that the emphasis must be on high risk radioactive sources, which raises the issue of the categorization of sources. We need to avoid having a number of categorizations which are inconsistent, and I am therefore concerned about the possibility that a categorization based on chronic effects of radiation — such as the one being developed in the USA — will prove to be inconsistent with the IAEA’s Categorization of Radiation Sources, which is based on deterministic effects.

B. DODD (IAEA): In the course of revising the IAEA's Categorization of Radiation Sources, we will soon request from the USA information necessary for determining whether the two categorizations can be harmonized, and if so, how. Also, we will involve the European Commission in the revision process, with a view to ensuring consistency with the envisaged European Council Directive to which Mr. Taylor referred in his presentation in Topical Session 1.

R.A. MESERVE (USA): I think the important thing is to have a transparent categorization approach which everyone understands as a basis for a sound international regime in the area of radioactive source security.

L. MATTEOCCI (Italy): To what extent will the interim guidance document on the security of radioactive sources that is being developed within the IAEA framework cover the security of sources during transport?

B. DODD (IAEA): We will try to ensure that there is consistency between the guidance relating to security during transport and that relating to security during storage and other stages of radioactive source management. A group of consultants last week considered issues connected with the security of radioactive sources during transport, and the results of the meeting will be reflected in the next draft of the interim guidance document.

L.A. BOLSHOV (Russian Federation): I was expecting this conference to focus mainly on radiological terrorism, for which even quite small radioactive sources may be sufficient. Instead, it seems to be focusing more on the safety of radioactive sources, an issue wherever nuclear energy is being used. Is the focus of this conference the right one?

R.A. MESERVE (USA): This topical session — on strengthening the long term control of radioactive sources — has perhaps focused more on safety, but there is a natural connection between controls for safety purposes and controls for security purposes, so that the issue of safety and that of security often tend to merge.

Jing ZHANG (China): In my opinion, the security of radioactive sources embraces two issues — the harm to a society as a whole caused by the malevolent use of a source and the harm to individuals caused by non-malevolent acts involving such sources — and I believe that addressing the former issue requires more financial and human resources than addressing the latter.

B. DODD (IAEA): In response to that comment I would note that my unit within the IAEA's Secretariat was established for the purpose of dealing with orphan source problems before the terrorist attacks of 11 September 2001 and that one reason why it was subsequently given additional responsibilities relating to the safety and security of radioactive sources was that most of the measures which one takes in order to prevent a source from becoming orphaned and harming individuals are very similar to, if not the same as, the measures necessary for preventing a source from falling into the hands of terrorists. Hence the financial and human resources necessary for addressing the issue of the harm to a society as a whole caused by the malevolent use of a radioactive source may not have to be so much greater than those necessary for addressing the issue of the harm to individuals caused by non-malevolent acts involving such sources.

STRENGTHENING CONTROL OF RADIOACTIVE SOURCES: THE IAEA MODEL PROJECT AS A CASE STUDY

A.M. CETTO
Department of Technical Co-operation,
International Atomic Energy Agency,
Vienna
E-mail: a.cetto@iaea.org

Abstract

The paper highlights and reviews the activities carried out under the IAEA Technical Co-operation (TC) Model Project on Upgrading Radiation Protection Infrastructure and its follow-up projects aimed at strengthening regulatory control of radiation sources, including control of exposure resulting from practices that involve the use of ionizing radiation. Through these activities, the participating Member States have been accelerating their compliance with the principal requirements of the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources. For more than the last three TC cycles, an increasing number of countries have been receiving special assistance under this project focused on the establishment and enhancement of efficient and sustainable regulatory mechanisms in order to comply with the IAEA's safety standards. Although the Model Project emphasizes primarily radiation and waste safety, the regulatory framework introduced in the participating Member States has also contributed appreciably to improving the security of radioactive sources and thus to minimizing the threat of their misuse.

1. INTRODUCTION

The IAEA's Technical Co-operation (TC) programme has always been a principal instrument for serving the Member States in the use of nuclear technology and techniques for peaceful purposes. At the same time, this programme has been contributing to fulfilling another fundamental mission of the IAEA — to provide for the application of the IAEA's safety standards in all its Member States. Although the IAEA's standards are not legally binding on Member States, they are binding for its own operations as well as for operations making use of materials, services, equipment, facilities and information made available by the IAEA or at its request or under its control or supervision. Consequently these safety standards are to be followed by all Member States in relation to operations assisted or organized by the IAEA.

The current IAEA safety requirements are presented in the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources (BSS) [1], developed in co-operation with other relevant international organizations and published in 1996. The intention of the BSS is to establish fundamental conditions for protection against the risk associated with exposure to ionizing radiation and to ensure the safety of radiation sources that may deliver such exposure. These standards rely on widely accepted radiation protection and safety principles, such as those recommended by the International Commission on Radiological Protection and other internationally recognized expert bodies. The BSS are consistent with the IAEA Safety Fundamentals publication Radiation Protection and the Safety of Radiation Sources [2].

The general requirements covering the scope, purpose and responsibilities are supplemented by requirements for practices and interventions, particularly important being the administrative and radiation protection requirements. The BSS contain six important appendices giving the detailed requirements for occupational, medical and public exposure control, for potential exposures and the safety of sources, for emergency exposure situations and for chronic exposure situations.

Implementation of the BSS in Member States requires the establishment of a national infrastructure with the following main elements: legislation and regulations, an independent or effectively independent regulatory authority empowered to authorize and inspect regulated activities and to enforce the legislation and regulations, sufficient resources and an adequate number of trained personnel. The applications of the BSS in developing an efficient national radiation protection programme should take into account local specific situations, technical resources, the scale of the use of radiation sources and other relevant factors.

The BSS provide the background and scientific foundation for the IAEA's radiation safety guides and other documents that serve as direct input to national legislation. They specifically require that all radiation sources be kept secure and under strict control, and call for immediate reporting to the regulatory authorities in the event that sources are lost, stolen, missing or abandoned. According to the BSS, the Member States should ensure adequate radiation protection and the safety of radioactive sources through relevant laws, regulations and other legislative tools which are implemented and executed by an appropriate regulatory authority with sufficient empowerment, qualified staff and funds to introduce a fully operational system of notification, authorization, inspection and enforcement. Although the IAEA's present safety standards include some specific security aspects of radiation sources, these standards should possibly be expanded to address some additional security issues in a more detailed and comprehensive way.

In accordance with the IAEA's Statute, those Member States which receive assistance in terms of radiation sources and related equipment or participate in the IAEA's activities are supposed to follow the BSS. This was also emphasized in the IAEA Board of Governors documents in 1999 [3] and 2001 [4], in which the implementation of the Model Project was evaluated, the project activities were described, and its continuation and expansion up to 2004 were confirmed.

2. MODEL PROJECT: OBJECTIVES AND SPECIFIC FEATURES

The primary objective of the Model Project is to assist the Member States in adopting appropriate safety measures in order to comply with the principal requirements of the BSS so that they are able to introduce an adequate radiation safety infrastructure. Such a system will allow the Member States to control occupational, medical and public exposures as well as to co-ordinate the necessary actions related to the preparedness for and response to radiological emergencies.

In the past the IAEA undertook a number of concrete actions aimed at developing infrastructures for ensuring safety in applications of nuclear and radiation technologies in its Member States. However, more careful evaluation carried out in the 1980s and at the beginning of the 1990s (more than 60 missions undertaken by Radiation Protection Advisory Teams and follow-up technical and expert missions) revealed major weaknesses, and it was concluded that many Member States lacked the minimum infrastructure for ensuring the appropriate regulatory control of radiation sources. This was why in 1993 a decision was taken to address this issue in a more systematic manner through an interregional Model Project, Upgrading Radiation Protection Infrastructure, which was included in the IAEA's TC programme as INT/9/143 in 1994.

Mainly for administrative and managerial reasons, Model Project INT/9/143 was structured into five well defined milestones:

Milestone 1 — the establishment of a regulatory framework — represented the very base of the infrastructure. It included such activities as the drafting, promulgation and implementation of a radiation protection law, the establishment of a regulatory authority, the adoption of regulations, and particularly the introduction of a system of notification, authorization, inspection and enforcement. An inherent part of this milestone was also the completion of a reliable inventory of radiation sources and facilities in each participating country. For this purpose a Regulatory Authority Information System (RAIS) was developed under Model Project INT/9/143. This inventory was the first attempt undertaken on such a scale at the international level to gather as accurate information as possible about existing radioactive sources, with special emphasis on the most powerful radioactive sources. The identification of these sources and the collection of more detailed information about them and their subsequent licensing represented the first tangible steps in bringing them under strict regulatory control. A similar priority was also applied to inspections of these sources. Attainment of Milestone 1 was regarded as the main immediate indicator of progress in meeting the Model Project's objectives.

The establishment of occupational exposure control comprising individual and workplace monitoring programmes was the main undertaking implemented under *Milestone 2*. The emphasis was placed on the monitoring and assessment of workers' exposure due to external radiation sources and from intakes of radionuclides.

Milestone 3 — the establishment of medical exposure control — was aimed at controlling and optimizing doses of patients in diagnostic radiology, nuclear medicine and radiotherapy. It included the introduction of appropriate quality assurance programmes, procedures for minimizing patients' exposure associated with diagnostic examinations and the prevention of accidents in the use of radiation or radionuclides for therapy treatment.

Radiation protection of the public and of the environment were the principal objectives addressed under *Milestone 4*, which also focused on the regulatory control of radioactive discharges to the environment, the management of radioactive waste, the control of consumer products containing radioactive substances and environmental monitoring.

The last task of the Model Project, *Milestone 5*, was aimed at the development of plans and the allocation of means to ensure the effectiveness of the national programme aimed at the preparedness for and response to radiological emergencies.

Later on, in 1997, the activities of the Model Project INT/9/143 were grouped into five new regional projects: RAF/9/024 for Africa, RER/9/056 for Europe, RLA/9/030 for Latin America, RAS/9/021 for East Asia and RAW/9/0006 for West Asia. This structure was maintained until the end of 2000, when more Member States joined the Model Project and it was split into two regional projects, one addressing original Milestones 1 and 2, and the other Milestones 3, 4 and 5. Consequently, since the TC 2001–2002 cycle there have been the following two projects in the five regions: RAF/9/027 and RAF/9/029 in Africa, RAS/9/026 and RAS/9/027 in East Asia, RER/062 and RER/065 in Europe, RLA/9/041 and RLA/9/044 in Latin America, and RAW/9/008 and

RAW/9/009 in West Asia. The first group of projects, directed towards the establishment of effective regulatory mechanisms for the control of radiation sources and occupational radiation protection programmes, focused on the attainment of Milestones 1 and 2 (National Regulatory Control and Occupational Radiation Protection Programmes). The second group, directed towards developing technical capabilities for sustainability, is aimed at medical and public exposure control and at the establishment of radiological emergency preparedness and response systems defined under Milestones 3, 4 and 5 (Development of Technical Capabilities for Sustainable Radiation and Waste Safety Infrastructure).

2.1. Participation

Altogether, 52 Member States interested in establishing regulatory control of radiation sources in line with the BSS have participated in the Model Project since 1995–1999: 17 in Africa, 5 in East Asia, 11 in Europe, 10 in Latin America and 9 in West Asia (Table I).

The interest and the expanded number of countries in the Model Project reflect its attraction and the success in its implementation. The establishment of essential regulatory mechanisms for the control of radiation sources was appreciated by the Member States, which valued particularly the IAEA's systematic approach in assisting them to meet the principal requirements of the BSS.

Later on, more countries, including new Member States, joined the project. By the end of September 2001, the IAEA had received requests from the following 29 countries (additional to the 52 Member States which participated in the first phase of the Model Project): in Africa — Angola, Burkina Faso, Egypt, Kenya, the Libyan Arab Jamahiriya, Morocco, Tunisia and the United Republic of Tanzania; in East Asia — China, Indonesia, Malaysia, Pakistan, Philippines, Singapore and Thailand; in Europe — Bulgaria, Croatia, Hungary, Malta, Portugal, Romania, Slovenia and Turkey; in Latin America — Ecuador, Haiti, Uruguay and Venezuela; in West Asia — the Islamic Republic of Iran and Kuwait.

In the current TC 2003–2004 cycle, there are altogether 88 Member States participating in the two Model Projects — the successors of the previous interregional and regional Model Projects. These include 30 countries in Africa, 12 in East Asia, 20 in Europe, 14 in Latin America and 12 in West Asia (Table I).

2.2. Implementation

Implementation started with the development of a work plan reflecting the countries' current situation, needs and priorities. Each Regional Manager,

TABLE I. MEMBER STATES PARTICIPATING IN THE MODEL PROJECT 1995–1999
(*regular type face: as of September 1999; italics: countries that joined later*)

Region	Participating countries (year of accession)
Africa (17 + 13 = 30)	17: Cameroon (1996), Côte d'Ivoire (1996), Democratic Republic of the Congo (1996), Ethiopia (1996), Gabon (1996), Ghana (1996), Madagascar (1996), Mali (1996), Mauritius (1996), Namibia (1996), Niger (1996), Nigeria (1996), Senegal (1996), Sierra Leone (1996), Sudan (1996), Uganda (1996), Zimbabwe (1996)
	13: Algeria (2002), Angola (2001), Benin (2003), Burkina Faso (2001), Central African Republic (2003), Egypt (2001), Kenya (2001), Libyan Arab Jamahiriya (2001), Morocco (2001), South Africa (2002), United Republic of Tanzania (2001), Tunisia (2001), Zambia (2002)
East Asia (5 + 7 = 12)	5: Bangladesh (1996), Mongolia (1996), Myanmar (1996), Sri Lanka (1996), Vietnam (1996)
	7: China (2001), Indonesia (2001), Malaysia (2001), Pakistan (2001),Philippines (2001), Singapore (2001), Thailand (2001)
Europe (11 + 10 – 1[a] = 20)	11: Albania (1995), Armenia (1996), Belarus (1996), Bosnia and Herzegovina (1996), Cyprus (1996), Estonia (1996), Georgia (1997), Latvia (1996), Lithuania (1996), Republic of Moldova (1996), Former Yugoslav Republic of Macedonia (1996)
	10: Azerbaijan (2003), Bulgaria (2001), Croatia (2001), Hungary (2001), Malta (2001), Portugal (2001), Romania (2001), Serbia and Montenegro (2003), Slovenia (2001), Turkey (2001)
Latin America (10 + 4 = 14)	10: Bolivia (1996), Colombia (1998), Costa Rica (1996), Dominican Republic (1996), El Salvador (1996), Guatemala (1996), Jamaica (1997), Nicaragua (1996), Panama (1996), Paraguay (1996)
	4: Ecuador (2001), Haiti (2001), Uruguay (2000), Venezuela (2002)
West Asia (9 + 3 = 12)	9: Jordan (1997), Kazakhstan (1996), Lebanon (1996), Qatar (1996), Saudi Arabia (1996), Syrian Arab Republic (1997), United Arab Emirates (1996), Uzbekistan (1996), Yemen (1996)
	3: Islamic Republic of Iran (2001), Kuwait (2001), Tajikistan (2002)

[a] Belarus completed its participation in the Model Project in 2000.

together with his national counterpart representing the Member State, finalized a country specific work plan which took into account such documents available from the IAEA as the Country Programme Framework and Country Radiation and Safety Profile, as well as numerous expert and other reports containing information on the radiation protection situation in the country. The input regarding various technical aspects received from the Technical Officer from the IAEA Division of Radiation and Waste Safety was very constructive and useful.

The first steps in implementing Model Project objectives in most countries included the drafting of laws and regulations, the establishment of a core of the national regulatory authority, and the recruitment and training of personnel. In parallel, the introduction of a system of notification, authorization and inspection of radiation sources along with a national inventory of radiation sources were assigned the highest priorities, in order to provide a basis for reliable regulatory control of radiation sources and to reduce the potential for radiological accidents. These activities took a great deal of time, particularly as far as the promulgation of radiation related laws was concerned, since in some countries, for various reasons, this process lasted from one to two years.

In each work plan, the obligations both of the participating country and of the IAEA were specified for effective implementation of the project within the planned time frame. The intention was that the infrastructure to be established or upgraded to a level commensurate with the extent of the radiation practices in a given country should ensure compliance with the BSS.

A typical work plan addressing individual milestones contains the following major elements:

Milestone 1

— Inventory of radiation sources (the use of RAIS);
— Laws, decrees, acts, principal regulations;
— Establishment of an independent regulatory authority;
— National regulatory programme;
— Specific regulations, codes of practice, guides;
— System of notification, authorization, inspection and enforcement.

Milestone 2

— Assessment of exposure due to external sources;
— Assessment of exposure due to intake of radionuclides;
— Workplace monitoring;
— Dose management system.

Milestone 3

— Radiation protection in diagnostic radiology, radiotherapy and nuclear medicine;
— Licensing, inspection and enforcement in regulatory control of medical sources and practices;
— Quality assurance and control;
— Justification and optimization leading to reduction of patient doses;
— Introduction of national guidance levels.

Milestone 4

— Justification, optimization and limitation of public exposure;
— Control of radioactive discharges;
— Environmental monitoring;
— Monitoring of consumer products;
— Radioactive waste management;
— Transport of radioactive sources and materials.

Milestone 5

— Development and implementation of a national plan and procedures for preparedness for and response to radiological emergencies;
— Establishment of a national co-ordination committee or body to deal with radiological emergencies.

In order to implement all the above mentioned tasks, the IAEA provided assistance in the following modalities:

(1) Expert services;
(2) Equipment for inspection, quality control and radiation monitoring;
(3) IAEA and other relevant documents and publications;
(4) Software package RAIS, including expert services for installation and training;
(5) Postgraduate Educational Course on Radiation Protection and the Safety of Sources;
(6) Regional, subregional and national training courses;
(7) Teaching materials for training courses;
(8) External lecturers for training courses;
(9) Fellowships;
(10) Scientific visits;

(11) Participation in international conferences, workshops and intercomparisons.

As can be seen from the above list, special attention has been paid to training, which includes standard specialized courses for regulatory authority staff and users of major radiation facilities. In 2001 and 2002 there were a number of regional training courses (RTCs) as well as Postgraduate Educational Courses in Radiation Protection and the Safety of Radiation Sources (PGECs) organized in each region: 12 RTCs (more than 250 trainees) and 3 PGECs (52 graduates) in Africa, 6 RTCs (attended by about 200 participants) and 2 PGECs (33 participants) in East Asia, 15 RTCs (more than 300 participants) and 2 PGECs (40 participants) in Europe, 6 RTCs (more than 150 participants) and 2 PGECs (30 professionals trained) in Latin America, and 11 RTCs (over 300 participants) and 1 PGEC (40 participants) in West Asia. In addition, many training events at a national level took place in the same period, e.g. about 15 national courses in Europe (attended by more than 300 participants) and 8 national training courses in Latin America (about 240 persons trained).

In the implementation of the Model Project, a special role has been played by monitoring missions undertaken by the regional managers, who met not only with their counterparts but also in many cases with high ranking government officials and parliamentarians, such as premiers, vice premiers, ministers, deputy ministers, permanent secretaries, speakers of parliaments and deputies. These meetings were instrumental in completing such tasks as the promulgation of laws, the establishment of regulatory authorities and the securing of appropriate funding.

The IAEA's Division of Radiation and Waste Safety provided technical support aimed at the attainment of all five milestones. The IAEA's Office of Legal Affairs provided valuable advice on the drafting of legislation (Milestone 1). The IAEA's Division of Human Health contributed to the technical support necessary for the implementation of Milestone 3. In addition to the in-house expertise, a large number of international experts were employed for implementation of specific project tasks.

2.3. Challenges

The intention of the Model Project was to bring regulatory control of radiation sources in line with the internationally agreed and adopted safety standards in order to allow the Member States to participate in all IAEA activities and operations, including receiving the IAEA's assistance with regard to radiation sources and equipment for their various applications.

The implementation of the Model Project has been affected by many difficulties, which considerably delayed the achievement of its specific objectives in some participating Member States. The originally set programme and time schedules were found to be too optimistic and had to be reconsidered to plan a more realistic approach taking into account the situation in the regions.

Some of the reasons why many countries were not able to attain the principal requirements were also mentioned in an IAEA Board of Governors document [4]:

— Time consuming legislative and regulatory procedures;
— Institutional instability;
— Budgetary constraints, resulting among other things in high turnover of qualified staff;
— Unfocused regulatory structures (overlapping responsibilities);
— Limited regulatory independence and empowerment;
— Inadequate support at the decision making level;
— Insufficient financial and technical resources, trained staff and support services.

3. RESULTS ACHIEVED

The results achieved under the Model Project were independently evaluated by more than 30 peer reviews and were positively appraised by the IAEA Board of Governors in 1999 and 2001.

The Model Project has had a significant impact on improving the regulatory control of radiation sources and has contributed immensely to the safety and security of radioactive sources in all regions. Its programming and implementation had to take into account the specific local situation, needs, available resources and priorities of the individual countries. The Model Project is a good example of an IAEA initiative involving an active approach rather than the traditional reactive approach in assisting the Member States through technical co-operation and know-how transfer.

3.1. Africa

Since January 2001, the project RAF/9/027 (Milestones 1 and 2) has involved the participation of 15 countries. Pursuant to the recommended Board action, three new Member States of the IAEA — Benin, Botswana and the Central African Republic — were integrated, upon their request, into the project in 2003.

As of January 2001, the project RAF/9/029 (Milestones 3, 4 and 5) included ten participating countries. Additionally, Algeria, South Africa and Zambia acceded to the project, upon their request, in 2002.

It is noted that all 15 countries which have participated in the first phase of the Model Project have progressed further in setting up or updating a national inventory of radiation sources using the computer aided RAIS provided by the IAEA. This was of major importance in ensuring improved regulatory control and the security of radioactive sources in these countries. Project assistance in this respect has been prioritized for those Member States which joined the IAEA in recent years (Angola and Burkina Faso) and where the system is still at its initial stage.

National training courses on radiation protection and on the security of radioactive sources were supported in Uganda. The courses were addressed to officers of law enforcement agencies.

The following other major developments concerning RAF/9/027 are highlighted:

(a) Enabling legislation was promulgated in Cameroon, the Democratic Republic of the Congo (DRC), Gabon, Mali and Sierra Leone.
(b) Regulations or decrees establishing the regulatory authority, as well as those governing different aspects of radiation safety and the security of radioactive material, were enacted in Cameroon, the DRC, Gabon, Mali, Madagascar and Sierra Leone.
(c) A system for TLD based individual monitoring for external occupational exposure control was provided to Angola, Benin, Burkina Faso and Nigeria, and was upgraded in Mauritius, Morocco, Namibia, Niger and Sudan.

Major developments under RAF/9/029 concerned programmes for quality assurance/quality control in diagnostic radiology. Such programmes were initiated or strengthened at principal institutions in the public health sector of several countries (Egypt, Ethiopia, Ghana, Kenya, Libyan Arab Jamahiriya, Morocco, Sudan, United Republic of Tanzania and Tunisia). Implementation of programmes for public exposure control, with emphasis on the safety and security of radioactive waste, progressed in all participating countries. Similarly, action to establish a national plan for response to radiological emergencies was initiated by all participating countries following regional training courses addressing this issue held in November 2000 and March 2003. Significant progress to this effect has been reported by Egypt, Ethiopia and Ghana.

The regional project on Postgraduate Training in Radiation and Waste Safety (RAF/9/028), established in 2001 and complementary to both regional

Model Projects, has continued to address the Member States' needs for capacity building and qualified specialists in this field. In addition to the fourth PGEC in English, the first university based PGEC for the French speaking countries of Africa was organized in the newly established training centre in Rabat, Morocco. Thus the number of course participants supported by the IAEA doubled to reach 30 in 2002.

3.2. East Asia and Pacific

Twelve countries in the East Asia region are currently participating in both Model Projects RAS/9/026 on National Regulatory Control and Occupational Radiation Protection Programmes and RAS/9/027 on Development of Technical Capabilities for Sustainable Radiation and Waste Safety Infrastructure. The countries are Bangladesh, China, Indonesia, Malaysia, Mongolia, Myanmar, Pakistan, Philippines, Singapore, Sri Lanka Thailand and Vietnam. Five of these countries (Bangladesh, Mongolia, Myanmar, Sri Lanka and Vietnam) have been participating from the first phase of the programme, which began in 1995.

Out of the 12 participating Member States, 9 (Bangladesh, China, Indonesia, Mongolia, Philippines, Singapore, Sri Lanka, Thailand and Vietnam) are considered to have completed all tasks related to the establishment of a regulatory infrastructure (Milestone 1), thereby complying with the IAEA's principal radiation safety requirements as defined in the BSS. Of the remaining three countries, Pakistan and Malaysia are at an advanced stage of implementation of Milestone 1. It is anticipated that these countries will meet the milestone by the end of 2003.

Five of these countries have established regulatory authorities that are independent from government agencies with responsibilities for the promotion of the use of sources of ionizing radiation, a requirement of the BSS. An additional three countries (Bangladesh, Thailand and Vietnam) are in the process of developing an all-encompassing umbrella of nuclear legislation that will eventually restructure the roles and responsibilities of their institutions and establish the independence of the regulatory body. This umbrella nuclear legislation will enhance the legal arrangements for radiation protection and nuclear safety and will incorporate a number of international treaties such as safeguards, the NPT and physical protection.

Ten of the 12 countries (China, Indonesia, Malaysia, Mongolia, Pakistan, Philippines, Singapore, Sri Lanka, Thailand and Vietnam) have established the essential elements for the control of occupational exposure (Milestone 2) as stipulated in the BSS. Bangladesh is at an advanced stage of implementation of this milestone.

The conclusion that the above countries have met Milestones 1 and 2 is based on the current evaluation of the project implementation as well as verification by independent peer reviews that were carried out in all of these countries.

Eleven countries — all except Singapore — are at various stages of programme implementation for the remaining elements of the principal requirements of the BSS, namely medical and public exposure control, and planning and preparedness for radiological emergencies. The radiation protection infrastructure in Singapore already meets all five project milestones.

The country specific work plans developed under the Model Projects for each of the participating Member States contain some elements which, in addition to the standard elements of radiation protection infrastructure, specifically address various aspects related to the security of radioactive sources.

In conclusion, all participating Member States in the region except for Myanmar have established a radiation source notification system and a source authorization process that meet international standards. The regulatory body has developed the required standard of regular inspections of those sources and radiation practices.

3.3. Europe

At present in the European region, out of 20 participating Member States, 12 (Albania, Belarus, Bulgaria, Cyprus, Estonia, Georgia, Hungary, Latvia, Lithuania, Republic of Moldova, Romania, Turkey) are considered to be in compliance with the IAEA's principal radiation safety requirements as defined under Milestones 1 and 2. This conclusion is based on the current evaluation of the project implementation and has been verified by peer reviews that were carried out in most of these countries. Independent reviews in the remaining countries will be organized soon to complete this assessment. In addition, three of the participating countries (Estonia, Latvia and Lithuania) have even claimed that they were able to attain all five milestones. In fact, they will be the first among more than 80 countries to successfully complete all tasks of the Model Project.

The implementation of the project in Europe was negatively affected by such factors as the following. (a) The newly independent countries of the former Soviet Union (Armenia, Azerbaijan, Belarus, Estonia, Georgia, Latvia, Lithuania and the Republic of Moldova) and to a certain extent also countries of the former Federative Socialist Republic of Yugoslavia (Bosnia and Herzegovina, Croatia, Serbia and Montenegro, Slovenia and the Former Yugoslav Republic of Macedonia) had to build their regulatory mechanisms from the beginning, since previously the control of radiation sources was centralized, including technical support services. (b) Economic circumstances in these countries as well as in some other central European countries have not allowed them to provide the regulatory authority with sufficient resources (Armenia, Bosnia and Herzegovina, Georgia and the Republic of Moldova still belong to the least developed countries). (c) The transition from a centralized system to a market economy system has required the adoption of a great many different laws, causing a substantial delay in promulgating radiation protection laws in some of the above mentioned countries. (d) A number of countries (Albania, Armenia, Bosnia and Herzegovina, and Georgia) have been going through a difficult period tainted by civil unrest, war or regional conflict, which has also slowed down the implementation process. There have also been countries where the central governments are still not in full control of their entire territories (Azerbaijan, Georgia and the Republic of Moldova), a situation which may create a breeding ground for the increasing occurrence of orphan sources and illicit trafficking.

On the other hand, however, there have also been stimulating aspects that auspiciously accelerated the process of complying with the BSS requirements: (a) The countries interested in joining the European Union (EU) wanted to use the Model Project as a vehicle for achieving compliance with the EU Directives regarding radiation protection, since the BSS and these Directives are basically compatible. (b) Some countries realized that the IAEA would not be in a position to provide them with radiotherapy or other high activity sources (badly needed in these countries) unless they attained Milestones 1 and 2.

The following are a few examples of how the Model Project contributed to solving concrete problems related to the security of radioactive sources. (a) Persons trained under the Model Project participated in the location, treatment and safe disposal of a number of ^{226}Ra and other sources (mainly used in lightning rods) in Bosnia and Herzegovina. (b) Staff members of the regulatory authority (trained under the Model Project) successfully participated in a search action aimed at regaining control over very high activity ^{90}Sr sources used in radioisotope thermoelectric power generators abandoned in unknown remote locations in Georgia, where the regulatory authority (established under the Model Project), in co-operation with the IAEA, was able to co-ordinate activities of local law enforcement organs in this well publicized search. (c) The regulatory authority in the Republic of Moldova managed to identify and assess the safety conditions of strong ^{60}Co and ^{137}Cs disused irradiator sources. Some of them were later transferred from the user's inadequate premises to a radioactive waste site where their security conditions will be further upgraded (also with additional resources provided by the United States Government through the Department of Energy, whose experts recently visited the Republic of Moldova to discuss the necessary details — a supplementary action that was closely co-ordinated with the IAEA in order to achieve the maximum synergetic effect). (d) The regulatory authorities in the Baltic countries (Estonia, Latvia and Lithuania) located and secured a great number of industrial sources found in collapsed or abandoned factories.

In this TC cycle, two follow-up Model Projects are being implemented: RER/9/062 on National Regulatory Control and Occupational Radiation Protection Programmes, and RER/9/065 on Development of Technical Capabilities for Sustainable Radiation and Waste Safety Infrastructure. In the first project, nine countries (Armenia, Azerbaijan, Bosnia and Herzegovina, Croatia, Malta, Portugal, Serbia and Montenegro, Slovenia and the Former Yugoslav Republic of Macedonia) of the region are participating, while 11 countries (Albania, Bulgaria, Cyprus, Estonia, Georgia, Hungary, Latvia, Lithuania, the Republic of Moldova, Romania and Turkey) are engaged in the second project. The work plans for both these Model Projects contain some elements which, in addition to the standard elements of radiation protection infrastructure, also specifically address various aspects related to the security of radioactive sources.

3.4. Latin America

Project RLA/9/041 (Milestones 1 and 2) has involved 14 countries, including Ecuador, Haiti, Uruguay and Venezuela, which joined the project in January 2001.

The main achievement during this period was that three new radiation protection laws were discussed in the field (Colombia, Costa Rica and El Salvador) — through expert missions with relevant national authorities — and the said Member States sent official missions to the IAEA for further discussions. Two radiation protection laws have been approved and put in force. All the countries already have national inventories of radiation sources, with most of them using the computer system RAIS provided and set in operation with the support of IAEA experts. The national inventory of sources has maintained good control over and increased the security of the sources.

Another relevant development that should be highlighted is the Regional Personal Monitoring Intercomparison exercise involving the whole Latin American region, since all participating countries in the region (with the exception of one country new to the project) already have in place individual external monitoring services working properly. Now the objective in the region is improvement of the quality and reliability of the measurements and also of the procedure to authorize private services under a quality scheme.

A PGEC is being developed under RLA/9/041 in accordance with the international syllabus approved by the IAEA, taking advantage of the experience and capabilities in these matters of the Argentine nuclear regulatory authority. During this period about 45 professionals have been trained in various aspects of radiation protection in order to increase the number of qualified specialists in this field in the region.

Regarding Milestones 3, 4 and 5, under Project RLA/9/044, the most relevant achievement that should be mentioned is in the field of Emergency Preparedness and Response (Milestone 5), realized mainly through a national training course carried out by the IAEA with the support of regional experts. These training activities are based on a standard package developed by the IAEA. Currently nine countries have a national emergency plan at different levels of implementation. It is expected that during 2003 at least another three countries will have put in place their national emergency plan.

Regarding Milestone 4, Public Exposure Control, several expert missions have taken place to draft national regulations and also to implement activities relating to waste safety.

In the Latin American region, out of 14 participating Member States, 11 (Bolivia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Nicaragua, Panama, Paraguay, Uruguay and Venezuela) are in compliance with Milestones 1 and 2. Compliance in most of the countries has been verified by peer review missions. Another two countries have made significant progress but still need to exert more effort to attain both milestones.

Four countries out of the 14 have made relevant progress in all the milestones, and most probably they would be able to start in the very near future to implement their own national radiation protection project.

The development of Milestone 5 in Latin America has been successfully implemented with the corresponding technical units of the Division of Radiation and Waste Safety in almost all Model Project countries, and actions are being taken to establish the national emergency system with the trained personnel and appropriate equipment.

3.5. West Asia

Significant progress has been achieved through assistance provided under regional Model Projects RAW/9/008 on National Regulatory Control and Occupational Radiation Protection Programmes and RAW/9/009 on Development of Technical Capabilities for Sustainable Radiation and Waste Safety Infrastructure to 12 participating countries in the West Asia region. Nine of these countries (Jordan, Kazakhstan, Lebanon, Qatar, Saudi Arabia, Syrian Arab Republic, United Arab Emirates, Uzbekistan and Yemen) have also been participating since 1996 in Model Project RAW/9/006. Two countries (the Islamic Republic of Iran and Kuwait) joined in 2001 and one (Tajikistan) joined in 2002. The progress made has been in spite of some adverse factors requiring more intense efforts, for example the participation of countries starting such activities from the beginning, the accession of some newly independent countries of the former Soviet Union and regional political instabilities.

Among the eight countries with radiation protection legislation in place, three have only recently established legislation (Jordan in 2001, United Arab Emirates and Qatar in 2002) and four have their draft law at the final stages of development at government or parliament level, with expected promulgation in 2003. Of the participating countries with draft regulations on radiation protection, transport of radioactive material and radioactive waste safety, nearly half also have radiation protection regulations in place, and others have legislation at various stages of approval. With the exception of two, all participating countries have a regulatory authority established at various stages of effectiveness in implementation. About seven countries have a system of notification, authorization and inspection established at various stages of implementation and enforcement, and in others the system is in the process of being established. All participating countries have received the IAEA software RAIS and have established radiation source inventories at various stages of completeness. A regional meeting held in Vienna on 27 May 2002 (prior to a regional co-ordination meeting of the two Model Projects on 28–31 May 2002) aimed at enhancing the awareness of the counterparts and senior decision makers of the two Model Projects in the West Asia region of the importance of the security of radiation sources.

All the participating countries in the region have adequate individual external monitoring equipment and dosimeters in place. Except for one new Member State, all others have trained staff with an operational national individual monitoring service offering a variable coverage of radiation workers at national level. As regards internal exposure monitoring, efforts have been initiated to establish the programme in countries having justified need through a regional training course in 2002, fellowship training and expert missions. A regional intercomparison exercise on quality assessment of the individual external monitoring services provided has been initiated.

For medical exposure control, a systematic approach is being developed, in particular in diagnostic radiology. The countries were assisted through regional and national training courses, fellowships and scientific visits, and expert missions, as well as the provision of quality control equipment. Notable progress has been made in the region towards establishing national pilot projects in a few selected hospitals in countries such as Jordan, Kazakhstan, the Syrian Arab Republic and the United Arab Emirates, as well as establishing the programme at hospital level in some countries. Kazakhstan has also nationalized medical exposure control through a national conference on diagnostic radiology.

With respect to public exposure control, support has been provided on some aspects of this milestone with emphasis on human resources development, and the safety and security of radiation sources. Some countries are more advanced than others in terms of environmental and food monitoring, safety and security of radiation sources and waste management, transport of radioactive material, etc. Participation through the Model Project in a tripartite mission (USA–Russian Federation–IAEA) to secure physical protection of waste facilities in Tajikistan has been an added value in the implementation of this milestone. However, a systematic approach to fulfil the requirements of this milestone will be implemented in countries that have met the major requirements of Milestones 1 and 2.

The development of an emergency preparedness and response plan at both national and institutional levels has been given a high priority; it has been established, in particular, in the work plans for 2002 and 2003, and is in progress in all countries in the region. However, it should be noted that implementation of a plan at a national level requires a fully operational regulatory authority. Two regional training courses, fellowship training and the provision of emergency tools are in progress for 2003.

The harmonization and co-ordination of the above mentioned activities in the region are realized through regional co-ordination seminars, peer review missions, expert missions, monitoring missions, etc. Eight countries have been peer reviewed and at least three peer review missions will be fielded in 2003. Priority was given to training activities under which over 600 technical staff of regulatory authorities and user organizations were trained through 11 regional and 12 national specialized training courses in 2001 and 2002. In particular, over 40 participants from West Asia and also some from the African region have graduated from three consecutive one-year PGECs in Arabic held in the Syrian Arab Republic. Extended efforts are under way at regional and national levels.

3.6. Quantification of overall results

The achievement of Model Project objectives and their quantification have not been an easy task because of the complexity of the project. In addition to the assessment made by the regional managers and the conclusions drawn from a number of end-of-mission reports, the most impartial appraisal has come from peer review missions. Such evaluations have usually brought a great deal of valuable information that the Regional Managers could use in their work aimed at the completion of all milestones in their regions.

The results accomplished under the Model Project have also been reported in the IAEA Bulletin [5–7] and at international conferences and symposia [8–14]. In addition, the background and origin of the Model Project as well as its implementation have been described in detail in a leading radiation protection journal [15].

Table II presents an attempt to quantify the overall results achieved in the Model Project in all five regions with respect to the implementation of Milestone 1 (Regulatory Framework). Table III gives some data regarding the implementation of Milestone 2 (Occupational Exposure Control).

The financial situation and the funds spent on activities implemented under the Model Project in 1996–2002 are shown in Table IV.

3.7. Present implications regarding the security of radioactive sources

The BSS require that all radiation sources be kept secure under strict control and call for immediate reporting to the regulatory authorities in the event that sources are lost, stolen, missing or abandoned. According to the BSS, Member States should ensure adequate radiation protection and the safety of radioactive sources through relevant laws, regulations and other legislative tools that are implemented and executed by an appropriate regulatory authority.

Certain measures to counter the malevolent misuse of significant radioactive sources have always been considered. Periodic inventories of sources and adequate records of accountability to ensure that the sources were secure and in their assigned locations were obvious basic requirements. In light of the events of 11 September 2001, however, it is considered necessary to introduce additional and more efficient measures to prevent illegal actions, including the unauthorized receipt, possession, use, transfer, import, export and disposal of radioactive sources, in order to hinder unlawful access to such sources. Here the national regulatory authorities should now play an even more significant role, as is being done in the case of Member States participating in the Model Project.

4. CONCLUSION

The IAEA's TC programme has played an important role in transferring know-how and strengthening local capacity in all fields related to the peaceful use of nuclear energy and various applications of techniques, including the implementation of adequate safety and security measures in the Member States. The IAEA considers that it is its responsibility to continue serving the international community in those often rather delicate and sensitive areas

TABLE II. SUMMARY OF PROGRESS IN IMPLEMENTING MILESTONE 1

Region (number of countries)	Law				Regulations				Regulatory authority		System of notification, authorization, inspection and enforcement			
	1a	1b	1c	1d	2a	2b	2c	2d	3a	3b	4a	4b	4c	4d
Africa (30)	18	4	6	2	18	4	6	2	21	9	10	5	9	6
East Asia (12)	12	—	—	—	11	—	1	—	12	—	12	—	—	—
Europe (20)	14	2	2	2	13	3	2	2	13	8	12	3	3	2
Latin America (14)	11	3	—	—	10	4	—	—	12	2	10	2	—	2
West Asia (12)	8	4	—	—	5	4	2	1	10	2	7	1	2	2

Law	Regulations	Regulatory authority	System of notification, etc.
1a Promulgated	2a Enacted	3a Established	4a In place
1b In final stage of development	2b In final stage of enactment	3b Not established	4b Being implemented
1c In draft form	2c In draft form		4c At initial stage of implementation
1d No action taken	2d No action taken		4d Not established

TABLE III. SUMMARY OF PROGRESS IN IMPLEMENTING MILESTONE 2

Region (number of countries)	Occupational exposure control					
	Individual monitoring			Workplace monitoring		
	a	b	c	a	b	c
Africa (30)	20	3	7	18	5	7
East Asia (12)	11	1	—	8	3	1
Europe (20)	16	2	2	12	4	4
Latin America (14)	12	1	1	8	4	2
West Asia (12)	11	1	—	6	4	2

Notes: a: National programme in place and operational;
b: National programme being established;
c: National programme not established.

TABLE IV. SUMMARY OF MODEL PROJECT FUNDING FOR 1996–2002 (US $)

	Model Project disbursement	Total disbursement (excluding in-kind)	Per cent attributed to Radiation Protection Model Project
1996	796 219	57 247 109	1.4
1997	2 573 841	59 608 762	4.3
1998	4 084 772	62 518 718	6.5
1999	4 653 419	62 839 099	7.4
2000	3 915 748	58 242 148	6.7
2001	5 231 969	72 486 812	7.2
2002	5 976 660	74 000 335	8.1

where safety and security have special meaning. The Department of Technical Co-operation, in co-operation with the other IAEA Departments, is prepared to intensify its efforts in taking possible steps to prevent the misuse of radioactive sources. This may include relevant training, provision of expert services and guidance, support for strengthening of national infrastructures, development of specific standards and procedures, and assistance in the implementation of additional preventive measures.

The position of the IAEA regarding its role has recently been formulated very clearly by IAEA Director General Mohamed ElBaradei: "What is needed is cradle to grave control of powerful radioactive sources to protect them against terrorism and theft. One of our priorities is to assist States in creating and strengthening national regulatory infrastructures to ensure that these radioactive sources are appropriately regulated and adequately secured at all times."

We believe that a joint effort and an integrated approach on the part of the IAEA and all responsible authorities and agencies, as well as those directly engaged in activities involving radioactive sources — suppliers, manufacturers, distributors, carriers and waste disposal operators — will result in a better solution to the problems associated with the security of radioactive sources. The IAEA, through its TC and other programmes, will intensify its efforts to facilitate and promote fruitful international co-operation in order to achieve the objectives of this important international conference.

ACKNOWLEDGEMENTS

The author is grateful to all Regional Managers responsible for the implementation of the Model Project in their respective regions (Mr. Sujit Dey, East Asia; Mr. Paulo Ferruz-Cruz, Latin America; Mr. Jozef Sabol, Europe; Mr. Karol Skornik, Africa; and Mr. Mehdi Sohrabi, West Asia) for their assistance and the data used in this paper.

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DISCUSSION

A.J.A. Al KHATIBEH (Qatar): Does the IAEA intend to provide equipment to Member States which it is helping to strengthen their radiation protection infrastructures?

A.M. CETTO (IAEA): Most IAEA TC projects have an 'equipment component', the decision whether to provide equipment to a particular Member State being taken on a case by case basis in the light of that Member State's specific circumstances.

B.-K. KIM (IAEA): With regard to the supply of equipment through the Model Project described by Ms. Cetto, the equipment component was higher in the early years of the Model Project than it is now. At the moment, about 20% of the Model Project expenditure is for equipment.

M. BAHRAN (Yemen): In 1997, my country had no radiation protection infrastructure. Now, its radiation protection infrastructure is probably one of the best in the region, thanks entirely to the Model Project.

S. KAKUSHADZE (Georgia): The Model Project was extremely helpful to my country in establishing a regulatory infrastructure capable of supporting efforts to find and deal with orphan sources.

K.S. PRADEEPKUMAR (India): Just one country with poor control over the radioactive sources within its territory may pose a challenge for all other countries, even if they have good control systems. It is therefore well worth while trying to ensure that all countries have the infrastructures necessary for effectively controlling radioactive sources.

A.M. CETTO (IAEA): I agree. The IAEA is endeavouring to convince those Member States without adequate infrastructures which are not participating in the Model Project to start participating.

A.J. GONZÁLEZ (IAEA): I also agree with Mr. Pradeepkumar. Unfortunately, there are about 50 countries which are not Member States of the IAEA and therefore cannot be covered by the Model Project. This is a very serious issue for which there is no easy solution.

A. NADER (Uruguay): As my country's counterpart for the Model Project, I would mention that, despite the fact that we started participating in it only in 2001, our radiation protection infrastructure has been greatly strengthened through it. We now have a sound regulatory framework, modern equipment and well trained people.

S.B. ELEGBA (Nigeria): Does the IAEA intend expanding the Model Project, from which my country also has greatly benefited, so as to include radioactive source security issues?

J. SABOL (IAEA): We recently incorporated a number of additional activities under Milestone 1 of the Model Project with a view to addressing security issues, as follows:

— Expediting the completion of national inventories of radioactive sources and searching for suspected orphan sources;
— Strengthening regulatory control over radioactive sources through the introduction of additional physical protection requirements, of additional authorization conditions and of additional inspections and enforcement actions;
— Helping to solve disposal or storage problems;

— Increasing the interactions and collaboration between national regulatory authorities and security agencies in Member States;
— Expanding the role and responsibilities of radiation protection officers at user organizations.

Many of the activities being carried out within the framework of the Model Project will be important for implementation of the revised Code of Conduct on the Safety and Security of Radioactive Sources.

A.J. GONZÁLEZ (IAEA): Of the additional activities just mentioned by Mr. Sabol, I would emphasize “expediting the completion of national inventories of radioactive sources and searching for suspected orphan sources”. A regulatory body cannot ensure the security of a radioactive source if it is unaware of the source’s existence. Without a complete national inventory, “security” is just an empty word.

PHYSICAL PROTECTION OF SIGNIFICANT RADIOACTIVE SOURCES: AN INDONESIAN PERSPECTIVE

M. RIDWAN
Nuclear Energy Control Board,
Jakarta, Indonesia
E-mail: mridwan@bapeten.org

Abstract

At present there is no treaty or convention requiring IAEA Member States using significant radioactive sources to protect them from being stolen or sabotaged. In the past, treaties and international regulations have focused only on certain radioactive material which can be used to make nuclear weapons. However, the picture has changed in the aftermath of the terrorist attacks of 11 September 2001, followed by the issue of a ‘dirty bomb’. The security of radioactive sources has been placed high on the international agenda. In Indonesia, radioactive sources — ^{60}Co, ^{137}Cs, ^{192}Ir, ^{241}Am, ^{90}Sr and others — are being extensively used in various applications. Some of these radioactive sources are in use and some are in storage. The hospitals, for example, have in their temporary storage facilities a number of disused radioactive sources, for example 114 ^{60}Co and ^{137}Cs sources with an activity of from a hundred millicuries[1] to a few thousand curies, and 352 ^{226}Ra sources, while industries keep 372 disused radioactive sources of various kinds in their temporary storage facilities. All of these materials are controlled by the Nuclear Energy Control Board of Indonesia (BAPETEN) according to the established legal procedures. Indonesia has sufficient legal instruments to deal with the physical protection of radioactive sources, not only in the licensing process for their application but in particular when they reach the end of their useful lives as radioactive waste. Although the legal requirement to license the temporary storage of radioactive waste in users’ premises is met by all users, the theft of 25 radioactive sources from Krakatau Steel Company in October 2000, the terrorist attacks of 11 September 2001 and the issue of a dirty bomb signalled BAPETEN to take a more serious look into the radioactive waste stored in users’ premises. The radioactive sources in use are considered to be properly physically protected, as they are important for the activities of the users. The same might not apply to the radioactive waste. BAPETEN also considers that the best place to store the radioactive waste is at the Waste Management Facility of the National Nuclear Energy Agency (BATAN), the competent national authority to manage radioactive waste in Indonesia. All BATAN’s nuclear facilities apply the physical protection system, as in all these nuclear facilities there are nuclear materials under IAEA safeguards and the Convention on the Physical Protection of Nuclear Material. An effort is being made to transfer all radioactive waste

[1] 1 Ci = 37 GBq.

from the users' premises to BATAN's Waste Management Facility by the end of 2004 at the latest, and to prevent the accumulation of waste at users' sites, BAPETEN will grant licences for temporary storage at users' premises for only two or three years. With all these approaches it could be considered that radioactive sources in Indonesia are under a good physical protection regime. It should be noted, however, that the need for co-operation becomes evident in situations where the effectiveness of the physical protection of radioactive materials in one State depends on the measures taken by other States. This is a global problem, requiring a global solution. For the Association of Southeast Asian Nations (ASEAN) region, for example, there are four regional instruments where the programme of physical protection of radioactive materials could be incorporated or strengthened, namely the SEANWFZ Treaty, the Regional Co-operative Agreement for Asia and the Pacific, the Regional Project of the IAEA Technical Co-operation programme, and the Forum for Nuclear Co-operation in Asia. The same approach could also be applied for the other regions where there is a regional co-operative agreement, such as AFRA for Africa and ARCAL for Latin America and the Caribbean. The Legal Committee of the General Assembly of the United Nations has before it a draft treaty on the suppression of acts of nuclear terrorism. Contrary to the IAEA Convention on Physical Protection, the draft treaty focuses on both kinds of radioactive material — weapons usable material and other material that can be dangerous to life and health.

1. INTRODUCTION

Today there is no treaty or convention requiring IAEA Member States using significant radioactive sources to protect them from being stolen or sabotaged. In the past, treaties and international regulation have focused on certain radioactive material which is considered dangerous because it can be used to make nuclear weapons. It is fissionable material, meaning it can, under certain circumstances, start a chain reaction which, if uncontrolled, can result in a nuclear explosion. Radioactive sources do not contain the type of material that would allow someone to build a nuclear bomb and trigger a major catastrophe. Though radioactive sources can be potentially dangerous for anyone coming into contact with them, they are safely used in everyday life for medical care and treatment, in industries, agriculture and science. However, there is increasing apprehension that radioactive sources could be turned into a terrorist tool — a 'dirty bomb'— which is also known as a radiological dispersal device (RDD). Such a weapon would not create a nuclear explosion; such a device, if exploded, would probably scatter radioactive material over a small area, restricting contamination to possibly a few city blocks. However, even if an RDD did not injure many people, it could certainly cause much terror and psychological distress, as well as mass panic. From the point of view of a terrorist, both types of radioactive material have their attraction. A terrorist might well try to acquire a nuclear material or a weapons usable material to try to construct a crude bomb; but a terrorist might also try to obtain the other type of radioactive material, i.e. a radioactive source, in an attempt to spread radiation for the purpose of causing mass panic and terror.

The need for securing or physically protecting radioactive sources is not new. However, reports of cases of illicit trafficking of radioactive materials still continue. The continued occurrence of cases of illicit trafficking in radioactive materials is a downstream consequence of inadequate protection, control or even management at the source of radioactive material. The risk of theft of radioactive sources should be considered as part of a comprehensive approach which also involves radiation safety and radiation protection considerations. Such a risk approach should take into account, in a graded manner, the wide spectrum of potential risk, at national and regional levels, and the range of consequences, including radiological contamination. Orphan radioactive sources — a term utilized by nuclear regulators to denote radioactive sources that are outside official (regulatory) control — are a widespread phenomenon in the Newly Independent States (NIS) of the former Soviet Union. Even the United States Nuclear Regulatory Commission reports that US companies have lost track of nearly 1500 radioactive sources within the country since 1996, and more than half have never been recovered. A European Union study estimated that every year up to about 70 sources are lost from regulatory control in the European Union. A recent European Commission report estimated that about 30 000 disused sources are held in local storage at the users' premises and are at risk of being lost from regulatory control [1]. There are also some orphan sources in some of the developing countries among the Member States of the IAEA. Sometimes these are called 'colonial sources', as the sources were left uncontrolled by the previous colonial authority, when, in the past, they decided to leave the country free.

Therefore it is not surprising that the security of radioactive sources has been placed high on the international agenda and that there have been substantial international efforts along this line.

2. NUCLEAR DEVELOPMENT AND RADIOACTIVE SOURCES IN INDONESIA

Indonesia has embarked on quite a large nuclear energy programme since the late 1970s, although it has no nuclear power plant in operation yet. Over the years, Indonesia has carried out many comprehensive studies on energy planning with the aim of introducing a nuclear power plant into the national grid. However, no decision has been made to date. At present it is operating three research reactors, one with a power of 30 MW; one nuclear fuel fabrication plant for research reactors; one experimental fuel fabrication plant for nuclear power; one radiometallurgy installation; and one interim storage for spent fuel. All seven facilities are under IAEA safeguards. In addition it is operating one isotope production facility, one uranium exploration camp in West Kalimantan and some research facilities. Except for the uranium exploration camp in West Kalimantan, all nuclear and research facilities are located at four sites, namely Serpong, Pasar Jumat, Bandung and Yogyakarta. All of these facilities have a proper physical protection system.

At present, radioactive sources are extensively used in various applications in Indonesia, such as in medicine, industry, mining, agriculture and research [2]. There are two types of radioactive sources used in Indonesia, unsealed and sealed. Unsealed radioactive sources are generally very much weakened by the time they cease to be used. In hospitals they are used for diagnostic as well as for treatment purposes. Except for those used for therapeutic purposes, these radioactive sources are of short half-life. Those used in industries, except for gauging, are also of short half-life.

There are 25 hospitals that provide radiotherapy services, utilizing the radioisotopes ^{60}Co, ^{137}Cs and ^{192}Ir, or linac and X ray machines. Sixteen of these hospitals have, in their temporary storage facilities, disused radioactive sources, i.e. 11 ^{60}Co or ^{137}Cs sources with an activity of a few thousand curies[2], 14 sources with a few curies, 89 sources with of the order of a hundred millicuries and 192 ^{226}Ra sources. The Department of Health stores 160 ^{226}Ra sources in its facilities.

Indonesia also operates three γ irradiation facilities with ten to a hundred thousand curies of ^{60}Co. There are also many companies in the paper, cigarette, food and steel industries that use radioactive sources such as ^{137}Cs, ^{60}Co, ^{241}Am, ^{109}Cd, ^{252}Cf, ^{244}Cm, ^{55}Fe, ^{85}Kr, ^{247}Pm and ^{90}Sr for gauging purposes. Many companies provide logging services; they use ^{153}Gd, ^{203}Hg, ^{226}Ra, ^{46}Sc, ^{124}Sb, ^{228}Th and ^{232}Th, while industrial radiography services are provided by many companies using ^{60}Co, ^{192}Ir and ^{75}Se. Some of these industries have, in their temporary storage facilities, many disused radioactive sources. There are 372 radioactive sources of various kinds temporarily stored.

In brief, the following are some radioactive sources commonly used and stored in hospitals, industries and mining:

— ^{60}Co sources of from a few millicuries to a hundred thousand curies are used for gauging, radiography, therapy and radiation sterilization.

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[2] 1 Ci = 37 GBq.

— ^{137}Cs sources of from a few millicuries to a few thousand curies are used for gauging, radiography, logging and therapy.
— ^{241}Am sources of only a few millicuries are used for gauging and logging.
— ^{109}Cd, ^{252}Cf, ^{244}Cm, ^{55}Fe, ^{85}Kr, ^{247}Pm and ^{90}Sr sources are used for gauging.
— ^{153}Gd, ^{203}Hg, ^{226}Ra, ^{46}Sc, ^{124}Sb, ^{228}Th and ^{232}Th are used by companies providing logging services.
— ^{192}Ir sources are used for radiography and therapy.

For radioactive sources which are not in use or are unlikely to be used in further applications, the licensee is advised to obtain a licence from the regulatory authority to temporarily store them in the local storage at the user's premises.

The Indonesian nuclear regulatory authority considers that the radioactive sources in use are properly physically protected, as they are important for the activities of the users. The same might not apply to the radioactive waste. The regulatory authority is now starting to look into this problem more seriously in view of the increasing number of accidents connected with disused radioactive sources, such as the accident in Goiânia, Brazil, in 1987, involving a discarded radioactive source in therapeutic equipment; the accident in Bangkok, Thailand, in 2000, also involving a discarded radioactive source in therapeutic equipment; and the accident in Cairo, Egypt, in the same year, involving a discarded ^{226}Ra brachytherapy source.

Many users still keep these disused radioactive sources at their premises by extending their storage licence from the regulatory authority. A licence extension is granted after the authority has received assurance that this radioactive waste is properly controlled and physically protected.

3. SECURITY APPROACH AT THE NATIONAL LEVEL

3.1. National legal instruments

In anticipation of the expansion of nuclear activities, the Indonesian Government enacted, on 10 April 1997, Act No. 10 of 1997 on Nuclear Energy. The Act fully separates the promotional and regulatory functions, in accordance with Articles 3 and 4, and establishes the regulatory body for the control of all applications of nuclear energy. The regulatory authority, Badan Pengawas Tenaga Nuklir (BAPETEN), or Nuclear Energy Control Board (NECB), was then established by Presidential Decree in May 1998 and is now in full operation.

Utilization of nuclear energy, as stipulated in Act No. 10/1997 [3], is defined as "any activity related to nuclear energy utilization that includes research, development, mining, fabrication, manufacturing, production, transportation, storage, transfer, export, import, decommissioning and radioactive waste management to enhance people's welfare".

The authority and responsibilities of BAPETEN are described in Articles 14–21, 27, 38 and 39 of the Act. Article 14, for example, stipulates, "the control of the utilization of all nuclear energy should be implemented through regulation, licensing, and inspection", and aimed, inter alia, to (Article 15):

— Assure the welfare, security and peace of the people;
— Assure the safety and the health of workers and public, and environmental protection;
— Prevent any diversion from the purpose of the nuclear material utilization.

BAPETEN's status, tasks, functions, structure and organization were established by Presidential Decree [4]; BAPETEN has, inter alia, the following functions:

— To establish the national policy in the field of the control of nuclear energy utilization;
— To implement the licensing and inspection of nuclear energy utilization, the construction and the operation of nuclear reactors, nuclear installations, nuclear material facilities and radiation sources, and the development of nuclear preparedness;
— To implement safeguards and the State system of accounting for and control of nuclear material (SSAC).

The Act stipulates that any activity related to the application of nuclear energy is required to be conducted in a manner which observes safety, security and peace, and which protects the health of workers and the public and the environment. This requirement is further implemented by Government Regulation No. 63 of 2000 on Radiation Safety, Government Regulation No. 64 of 2000 on Licensing, and some Technical Regulations issued by BAPETEN. Government Regulation No. 63 of 2000 [5] stipulates, inter alia, that the aim of the regulation is to ensure the safety, security, peace and health of the workers and the people and to protect the environment, while Government Regulation No. 64 of 2000 [6] stipulates, inter alia, that a physical protection system should be in place for those facilities that utilize nuclear materials.

Developments in civil nuclear programmes in Indonesia, as in many countries in the world, have resulted in there being an increasing number of radioactive sources both in use and in storage. Unless thoroughly controlled and protected at national and facility levels, these materials may be vulnerable to theft or sabotage. At present there are around 838 radioactive sources of various kinds temporarily stored as radioactive waste at users' sites.

With regard to waste management, the Act on Nuclear Energy stipulates the following:

> "Radioactive waste is defined as any radioactive material and any material as well as equipment that has been contaminated by radioactive material or becomes radioactive due to the operation of a nuclear installation and cannot further be used."

Further:

- Radioactive waste management shall be conducted to mitigate radiation hazards to the workers, the public and the environment (Article 22 (1)).
- Radioactive waste management shall be accomplished by the Executive Body, which may designate a state or private company or co-operative to conduct commercial waste management activities (Article 23).
- Users generating low and intermediate level radioactive waste shall be obliged to collect, segregate, or treat and temporarily store the waste before its transfer to the Executive Body (Article 24 (1)).
- The provisions on radioactive waste management, including waste transport and disposal, shall be further implemented by Government Regulation.

Article 25 prohibits the use of any part of Indonesian territory by any foreign country as a radioactive waste repository.

Government Regulation No. 26 of 2002 on Safe Transport of Radioactive Materials [7] and Government Regulation No. 27 of 2002 on Radioactive Waste Management [8] were issued to administer the requirements contained in these articles. Article 27 of Government Regulation No. 27 of 2000 stipulates, inter alia, that storage facilities for low and intermediate level radioactive waste and the final repository facilities for high level radioactive waste should be equipped with a physical protection system.

Further, BAPETEN Rule and Procedure No. 03/Ka-BAPETEN/V-99 on Safety of Waste Management [9] (which is now under revision) stipulates that users can temporarily store the radioactive waste at their premises, provided the waste is placed in containers and stored, preferably in a bunker, locked in a room with the radiation symbol (trefoil); this storage must be located far from the working area and surrounded with a fence.

These are all national legal instruments that BAPETEN should exercise with regard to the physical protection of radioactive sources in Indonesia.

3.2. International instruments

There is no binding international instrument pertaining to security or the physical protection of radioactive sources that can be used by the international community to require the countries utilizing significant radioactive sources to properly protect these sources from theft or sabotage.

However, to answer the needs of the nuclear community pertaining to security of radioactive materials, in 2000 the 44th Session of the IAEA General Conference endorsed, in Resolution GC(44)/RES/11, the action taken by the Board of Governors and invited Member States to take note of the Code of Conduct on the Safety and Security of Radioactive Sources [10] and to consider, as appropriate, means of ensuring its wide application. The Code does not obligate Member States to honour its contents; it only serves as guidance to States for, inter alia, the development and harmonization of policies, laws and regulations on the safety and the security of radioactive sources.

The objective of the Code of Conduct on the Safety and Security of Radioactive Sources is to achieve and maintain a high level of safety and security of radioactive sources through the development, harmonization and enforcement of national policies, laws and regulations, and through the fostering of international co-operation. In particular, the Code addresses the establishment of an adequate system of regulatory control from the production of radioactive sources to their final disposal, and a system for the restoration of such control if it has been lost.

One important point that the Code stipulates with respect to radioactive waste is the following:

> "Every State should, in order to protect human health and the environment, take the appropriate steps necessary to ensure that radioactive sources within its territory, or under its jurisdiction or control, are not stored for extended periods of time in facilities not designed for the purpose of such storage."

In addition, there is another international instrument that Member States could consider, i.e. the Convention on the Physical Protection of Nuclear Material, although it contains no obligations regarding the security of radioactive sources [11]. The Convention itself has been in force since 1987, with 71 States Parties to it. Indonesia ratified the Convention in the form of Presidential Decree No. 49 of 1986, which thereby laid the foundation for the measures for physical protection of nuclear materials in the country. Unfortunately, the Convention obligates States Parties to meet the defined standards of physical protection only for international shipments of nuclear materials, and to co-operate in the recovery of stolen nuclear materials. There is no obligation regarding nuclear materials in domestic use, transit or storage. The Convention also promotes international co-operation in the exchange of physical protection information. Indonesia has also adopted the recommendations for the physical protection of nuclear material against theft and sabotage contained in INFCIRC/225/Rev. 4. The Convention is now under review again by the international nuclear community with the purpose of modifying it to meet the present problem.

It should be noted, however, that the responsibility for establishing and operating a comprehensive physical protection system for radioactive sources rests entirely with the Government of the State. Member States of the IAEA, which bear an international responsibility with regard to the safety and security of nuclear activities, could to some extent voluntarily adapt and modify the requirement to establish a physical protection system for radioactive material contained in the Convention on the Physical Protection of Nuclear Material to include significant radioactive sources.

3.3. Physical protection of significant radioactive sources in Indonesia

Indonesia has sufficient legal instruments to deal with the physical protection of radioactive sources, not only in the licensing process for their application but in particular when they reach the end of their useful lives as radioactive waste. The national legal instruments meet the requirements contained in the international instruments discussed in the previous section.

The issuance of a licence to utilize radioactive sources is subject to the fulfilment of the requirements set out in Government Regulations [5–8], and in BAPETEN's rules and procedures [9, 12–17] derived from Articles 15–19 of Act No. 10 of 1997 on Nuclear Energy, such as those relating to procurement and import documents, technical specifications of the radioactive sources, facility design, necessary monitoring equipment, standard operating procedures, including handling of emergencies and waste management, and the availability of trained and certified personnel or a radiation safety officer at the user's institution. Even during the useful life of radioactive sources, prior approval of BAPETEN is required in respect of transfer, transport, resale, re-export or storage. If at a later time the source will no longer be in use, it is advised to arrange for temporary safe storage before the source is finally re-exported to the original supplier.

With all these national legal instruments and the practices being implemented in Indonesia so far, it is considered that all radioactive sources used in various applications in Indonesia are properly secured and protected, under proper control of the regulatory authority and in accordance with international requirements.

However, the theft of 25 radioactive sources (three of them were recovered) from Krakatau Steel Company in Cilegon, West Java, in October 2000 signalled BAPETEN to take a more serious look into the radioactive waste stored in users' premises.

The 25 radioactive sources stolen were used and disused sources of low radioactivity used for gauging purposes. Most them were ^{60}Co with an activity of the order of a millicurie, but one was ^{241}Am of 1 Ci activity. Of the 22 sources that were stolen and not later recovered, 14 were ^{60}Co of 1.9 mCi, 2 were ^{60}Co of 2.4 mCi, 4 were ^{60}Co of 2.9 mCi, 1 was ^{60}Co of 4.8 mCi and 1 was ^{241}Am of 1 Ci [18].

These radioactive sources are indeed of low radioactivity, which will not pose much danger to the public in general. The Emergency Preparedness Unit of BAPETEN immediately sent its staff to the site, to search for the stolen radioactive sources and try to find the track by which the sources were removed. The team recovered only three of the sources.

As legally required, the radioactive sources had been placed in their containers and stored in a bunker with a concrete cover, equipped with a chain to open the bunker, locked in a room located on the user's premises and surrounded with barbed wire.

Apparently there was negligence on the part of the security officers of the user. The thieves broke down the surrounding wall and took barbed wire with them in August 2000. The broken wall was not repaired properly, and a few weeks later, the thieves came back and saw that the broken wall was unrepaired. They entered the premises again, opened the door of the storage room by force and took all the metallic components from the room, including the chain. In October the thieves came again, and found that the wall was still unrepaired and that the storage room was still open (the door was unlocked). In the storage room they found nothing, and decided to open the bunker using a big wooden bar. There they found many metallic materials. They decided to take the materials with them, not knowing they were radioactive sources. Their interest was not in radioactive sources but in scrap that they could sell. After this incident, the security officers reported to the management and the management to BAPETEN.

After the incident, BAPETEN, as a temporary measure, sent its inspectors to carry out a special inspection at the user's premises, where radioactive waste was temporarily stored. Advice was then given to improve the physical protection system of the storage area or to move the radioactive waste to a more protected and/or isolated location, or wherever possible to transfer all these radioactive sources to the Waste Management Facility of BATAN in Serpong.

The radioactive sources located in four sites of BATAN's nuclear facilities are considered to be under good control and physically protected, as in these nuclear facilities there are nuclear materials under IAEA safeguards and the Convention on the Physical Protection of Nuclear Material. However, to check the physical protection system in those facilities, BAPETEN invited an International Physical Protection Advisory Service (IPPAS) mission to review the physical protection system in those sites subject to the international requirements. The IPPAS mission conducted its review in February 2001 and drew the following conclusions:

> "…BAPETEN was formed in 1998 and for just over two years has been working hard to bring the nuclear industry in Indonesia into line with internationally recommended physical protection practices. The IPPAS Team was impressed with the result so far achieved. In the opinion of its members much of what is required on the regulatory front is in place and they recommended changes only to some of the secondary legislations and regulations".
>
> "…of the three facilities, one (at Serpong) falls into Category II and the other two (at Bandung and Yogyakarta) into Category III for physical protection purposes. The physical protection regime in place at Serpong is not satisfactory for Category II sites. Investment in the physical protection system there is urgently required to make the site suitable for Category II quantities of nuclear material. The regime at Bandung and Yogyakarta, while requiring a lower level of physical protection than Serpong, does not fully satisfy the recommendation in INFCIRC/225/4".

The report and recommendation of the IPPAS Team were made after review of the sites in February 2001. The improvement of the physical protection regime as recommended by the IPPAS Team was then carried out, and the IPPAS Team will be invited again in 2004. Hence those radioactive sources located in four sites of the BATAN nuclear facilities could be considered to be under good control and physically protected.

BAPETEN considered that the measures taken up to that point were sufficient, as asking the users to transfer all radioactive sources to a BATAN facility would involve a certain amount of expense. However, the picture has changed in the aftermath of the terrorist attacks of 11 September 2001. The issue of a dirty bomb amplifies the problems of radioactive waste stored temporarily at users' premises. A certain policy was introduced by BAPETEN, namely to temporarily store all radioactive waste in the country at BATAN's nuclear facilities, where an adequate physical protection system is in place, or to transfer all radioactive waste to BATAN's Waste Management Facility for final storage, where the physical protection system is also applied, as according to the Nuclear Energy Act, BATAN is the competent national authority to manage radioactive waste in the country.

Immediately in the fiscal year 2002 BAPETEN organized three co-ordination meetings with the users, representatives of the Ministry of Health and BATAN, to sort out the radioactive waste temporarily stored at users' premises. During the co-ordination meeting it was agreed that all users, by the end of 2004, would transfer all radioactive waste to BATAN's Waste Management Facility at Serpong, 25 km southwest of Jakarta, and that to prevent accumulation of waste at users' sites, BAPETEN will grant licences for temporary storage at users' premises only for a minimum period of time — two or three years. This option is now being reviewed. With this set-up it is hoped that radioactive sources are properly secured in Indonesia, whether they are in use or in storage.

Indonesia has all the means necessary to properly protect all radioactive sources (and nuclear materials) in use and in storage. Act No. 10 of 1997 on Nuclear Energy clearly stipulates, "The control of the application of all nuclear energy is aimed to assure welfare, the security and peace of the people". Further Government Regulations derived from the Nuclear Energy Act also contain some paragraphs on the requirement to apply security to radioactive materials in use or in storage. BAPETEN was established with a clear mandate and legal authority, and with sufficient staff and funding. At present, BAPETEN is embarking on an intensive programme with regard to the safety and security of radioactive waste, with the particular aim of transporting all radioactive waste temporarily stored in users' sites to the site of the competent authority entrusted by the Nuclear Energy Act to manage the final repository for radioactive waste. In addition, BAPETEN is now reviewing all technical rules and guides issued to cover explicitly the importance of the physical protection of radioactive materials while in use or in storage.

3.4. Emergency preparedness

At the beginning of the establishment of BAPETEN, an Emergency Preparedness Unit was created to respond to any radiological emergency situation. The unit is under the Directorate of Inspection and Emergency Preparedness. An incident connected with the radioisotopes of logging equipment being stuck in a well was reported, and staff members of the unit were sent immediately to the location to provide proper advice on handling the problem. Another incident connected with the melting, through fire, of two casks, each containing ^{137}Cs sources of 15 and 50 mCi in gauging equipment belonging to a refinery company, was reported. The unit responded immediately by sending its staff to the site. Proper advice and an action plan were provided.

The Emergency Preparedness Unit, as mentioned earlier, was involved intensively in searching for the stolen radioactive sources from Krakatau Steel Company. It spent more than one month at the company site, not only to try to recover the stolen radioactive sources but also to organize a public information forum to explain the danger of radioactive sources to the people and inform the staff of local hospitals and clinics on how to recognize and initially respond to an accidental radiation injury. As stated earlier, the unit recovered only three of the stolen radioactive sources. No person with a radiation injury was reported coming to a local clinic or hospital for treatment.

3.5. Design Basis Threat (DBT)

To follow up the recommendation of the IAEA IPPAS mission to establish a national Design Basis Threat (DBT), BAPETEN, with the assistance of the IAEA, organized a National Workshop on DBT in December 2002. The Workshop was attended by representatives from BATAN, the national police department, the national intelligence agency and the army. The aims of establishing the national DBT are to:

— Develop and evaluate the existing physical protection regime in Indonesia;
— Help to define the characteristics of potential internal and external adversaries who would attempt the sabotage or unauthorized removal of radioactive material or the sabotage of a nuclear facility;
— Evaluate the licensing process for radioactive materials.

4. SECURITY APPROACH AT THE REGIONAL LEVEL

The security of radioactive materials has been a matter of national and international concern since the spectre of nuclear terrorism was raised by the terrorist attacks of September 2001. The need for international co-operation (as also stipulated in the Code of Conduct on the Safety and Security of Radioactive Sources) becomes evident in situations where the effectiveness of measures for the security of radioactive sources in one State depends on the measures taken by other States. Failure to take the appropriate measures could lead to unexpected consequences, such as theft leading to illicit trafficking of radioactive sources, which could further lead to a fatal consequence.

The fact that the security of radioactive sources in one State depends on the measures taken by other States can be seen from the IAEA report on the illicit trafficking of radioactive sources and nuclear materials recorded between 1993, when the programme started, and 2001, and confirmed by Member States. It can be seen in Fig. 1 that the majority of incidents of illicit trafficking of radioactive sources and nuclear materials (385 out of 416 cases, or 92.5%) took place in Europe, the Russian Federation and the NIS, while the remaining 7.5%, or 31 cases, took place in the rest of the world. The inadequate security system for radioactive sources or the presence of orphan sources in many of the NIS [1] caused a high number of illicit trafficking cases in many eastern European countries, in the Russian Federation and in Germany. The 385 illicit trafficking cases recorded during the last nine years are distributed among the following countries: eastern European countries 97 (25.2%), the Russian Federation 49 (12.7%), Germany 86 (22.4%) and the NIS 84 (21.8%), as can be seen in Fig. 2.

The number of illicit trafficking cases that took place every year from 1993 to 2001 can be seen in Fig. 3, which shows that the number of cases each year during that period, except for the years 1996–1998, is almost the same.

From Figs 1 and 2, it can be concluded that the security of radioactive sources in Asia and the Pacific area, particularly in countries belonging to

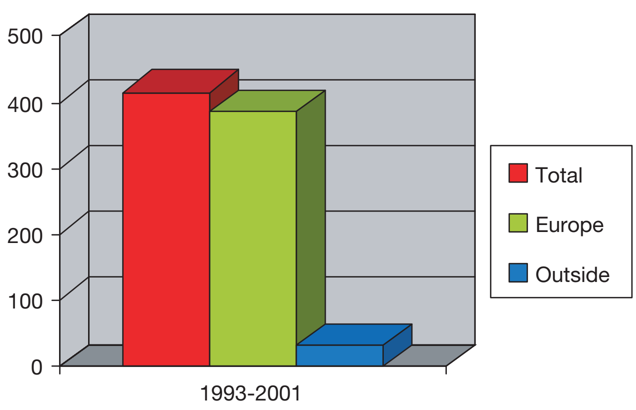

FIG. 1. Illicit trafficking of radioactive sources and nuclear material in the world. Red: total (100%); green: Europe and the NIS (92.5%); blue: rest of the world (7.5%).

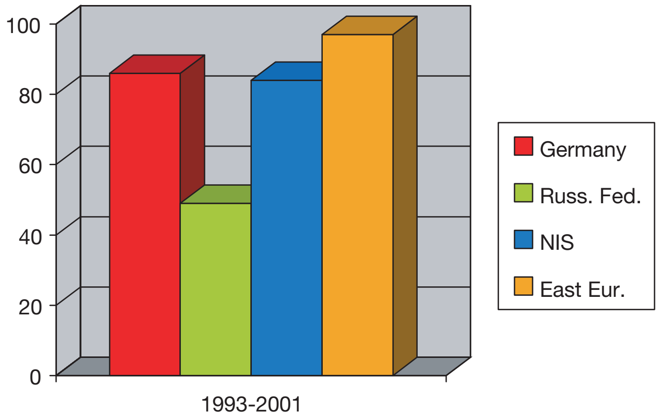

FIG. 2. Illicit trafficking of radioactive sources and nuclear material in the world. Red: Germany (86 cases, 22.3%); green: Russian Federation (49 cases, 12.7%); blue: NIS (84 cases, 21.8%); orange: eastern European countries (97 cases, 25.2%).

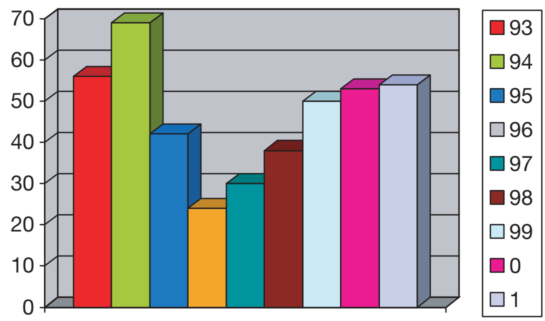

FIG. 3. Total number of illicit trafficking cases from 1993 to 2001. Red: 1993 (56 cases, 9 involving enriched uranium); green: 1994 (69 cases, 18 involving enriched uranium); blue: 1995 (42 cases, 12 involving enriched uranium); orange: 1996 (24 cases, 1 involving enriched uranium); dark green: 1997 (30 cases, 7 involving enriched uranium); dark red: 1998 (38 cases, 3 involving enriched uranium); light blue: 1999 (50 cases, 3 involving enriched uranium); rose: 2000 (53 cases, 4 involving enriched uranium); grey: 2001 (54 cases, 2 involving enriched uranium).

ASEAN, is particularly good, at least as shown by the nine years of data collection, i.e. from 1993 to 2001.

However, the picture might have changed after the 11 September 2001 terrorist attacks, the later emergence of the dirty bomb issue, and the bomb explosion carried out by a group of terrorists on the resort island of Bali in October 2002. A few days after the Bali explosion, the rumour of micro nuclear bomb devices having been used by the terrorists in Bali was spread among some leading media in Jakarta. Although BAPETEN was quite sure that the bomb explosion in Bali was a conventional one, to convince the public at large, BAPETEN sent its inspectors to Bali to monitor the radiation level at the explosion site and at some points around the site, including the airport. There was no increase of radiation level observed. A few samples were taken and sent to BATAN to analyse the possible existence of fission products. The result was negative — the bomb was of a conventional type.

The recent global security developments dictate that the nuclear community must undertake a far reaching new effort to strengthen the security of nuclear materials and radioactive sources. This is a global problem, requiring a global solution. The best global solution may be a mosaic approach, including national, bilateral or regional as well as international or multilateral pieces.

The need for co-operation becomes evident in situations where the effectiveness of the physical protection of radioactive materials in one State depends on the measures taken by other States. Taking into account the vulnerability of the ASEAN region with respect to nuclear smuggling and the illicit trafficking of radioactive materials, as most of the ASEAN countries contain many islands, such co-operation is of primary importance. Indonesia, for example, has 18 110 islands with 108 000 km of coastline. There are some instruments that could be explored to implement such co-operation in protecting radioactive materials from theft or sabotage among the ASEAN countries with the assistance of the IAEA.

4.1. Regional instruments

There are at least four regional instruments where the programme of physical protection of radioactive materials could be incorporated or strengthened, namely:

— Treaty on the Southeast Asia Nuclear Weapon-Free Zone;
— Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology for Asia and the Pacific;
— Regional Project of the IAEA Technical Co-operation programme;
— Forum for Nuclear Co-operation in Asia.

4.1.1. Treaty of the Southeast Asia Nuclear Weapon-Free Zone

On 15 December 1995 in Bangkok, the ten Heads of State of the ASEAN countries signed the Treaty on the South East Asia Nuclear Weapon-Free Zone, or the SEANWFZ Treaty. Indonesia then ratified the Treaty in 1997 as Act No. 9/1997 [19].

With regard to the utilization of nuclear energy, the Treaty stipulates, inter alia, the following (Article 4.2(b)):

> "...prior to embarking on its peaceful nuclear energy programme, to subject its programme to rigorous safety assessment conforming to guidelines and standards recommended by the IAEA for the protection of health and minimization of danger to life and property in accordance with Paragraph 6 Article III of the Statute of the IAEA".

To start facilitating such co-operation, Indonesia, with the assistance of the IAEA, organized, in May 2002, a Regional Workshop on Physical Protection and Material Security to Combat Illicit Trafficking. The Workshop was attended by participants from ASEAN Member Countries, namely Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam.

The Workshop Summary Statement includes the following:

— The Workshop expressed an urgent need to organize ASEAN regional networking on the development and establishment of nuclear safety and security; to exchange information concerning illicit trafficking among the ASEAN Member Countries.
— The Workshop encouraged States in the region co-operatively to use their expertise and resources to combat illicit trafficking.
— The Workshop recognized that the scope of a physical protection system should include other radioactive materials.

The Commission of the SEANWFZ Treaty is now seeking assistance from the IAEA in the implementation of the Treaty. The importance of having a physical protection regime in place for the safety and security of radioactive materials would be underscored by IAEA assistance to the Commission of the SEANWFZ Treaty in working out the mechanisms to implement the programme of physical protection of radioactive materials.

4.1.2. Regional Co-operative Agreement for Asia and the Pacific (RCA)

In the Asia and Pacific region, there is a regional framework agreement for multilateral co-operation among Member Sates under the aegis of the IAEA [20]. This agreement started in 1972 and now enjoys the participation of Australia, Bangladesh, China, India, Indonesia, Japan, Republic of Korea, Malaysia, Myanmar, New Zealand, Pakistan, Philippines, Singapore, Sri Lanka, Thailand and Vietnam, of which seven are countries belonging to ASEAN. Under the RCA, participating States, in co-operation with each other and the IAEA, seek to promote and co-ordinate co-operative research, development and training projects in nuclear science and technology through their appropriate national research institutions. The RCA Member States organize two annual meetings of the RCA National Co-ordinators, during the IAEA General Conference and the regular meeting in the region.

As the RCA is under the aegis of the IAEA, the IAEA could use this agreement as one of its instruments to enhance the security and the physical protection of radioactive sources.

4.1.3. IAEA regional programme

Every two years the IAEA seeks the approval or endorsement of the IAEA Board of Governors with regard to the Technical Co-operation programme the IAEA will implement with its Member States. Among the national Technical Co-operation programmes, there are also regional technical programmes for the countries in a certain region. This technical programme could be used by the IAEA as one of its instruments to enhance the security and the physical protection of radioactive sources.

4.1.4. Forum for Nuclear Co-operation in Asia

In 1990 the Atomic Energy Commission of Japan organized the first International Conference for Nuclear Co-operation in Asia (ICNCA), which afterwards was held annually till 1999. In 1999 it was decided to rename it the Forum for Nuclear Co-operation in Asia (FNCA) [21]. The participants of the Forum are nine countries, namely Australia, China, Indonesia, Japan, Republic of Korea, Malaysia, Philippines, Thailand and Vietnam. The FNCA is to be recognized as an effective mechanism for enhancing socioeconomic development through active regional partnership in the peaceful and safe utilization of nuclear technology. At present, when we talk about the safe utilization of nuclear technology, our standpoint always implies the safety and security of nuclear technology utilization. As all nine participating countries of the FNCA are IAEA Member States, in this respect the IAEA could use the FNCA as an instrument to encourage all countries to enhance the security and the physical protection of radioactive sources.

The regional approach taken for the Asia and Pacific region in general, and for ASEAN countries in particular, could also be used for other regions where there is a regional co-operative agreement, such as AFRA for Member States in Africa and ARCAL for Latin America and the Caribbean, similar to the RCA for the Asia and Pacific region. In Latin America and the Caribbean there is also the Treaty for the Prohibition of Nuclear Weapons in Latin America and the Caribbean, which is similar to the SEANWFZ Treaty.

5. CONCLUSION

Indonesia has sufficient legal instruments to deal with the physical protection of radioactive sources, not only in the licensing process for their application but in particular when they reach the end of their useful lives as radioactive waste. The national legal instruments meet the requirements contained in the international instruments.

A policy has been introduced to temporarily store all radioactive waste at BATAN's nuclear facilities, where an adequate physical protection system is in place, or to transfer all the radioactive waste to BATAN's Waste Management Facility for final storage, where the physical protection system is also applied, as according to the Nuclear Energy Act, BATAN is the competent national authority to manage radioactive waste in the country. In the future, BAPETEN will grant licences for temporary storage at users' premises only for a minimum period of time — two or three years. This option is now being reviewed.

As for the physical protection of radioactive sources at a regional level, there are at least four regional instruments where the programme of physical protection of radioactive materials could be incorporated or strengthened, namely:

- Treaty on the Southeast Asia Nuclear Weapon-Free Zone;
- Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology for Asia and the Pacific;
- Regional Project of the IAEA Technical Co-operation programme;
- Forum for Nuclear Co-operation in Asia.

Finally, the Legal Committee of the General Assembly of the United Nation has before it a draft treaty, initially proposed by the Russian Federation, on the suppression of acts of nuclear terrorism. In contrast to the IAEA Convention on Physical Protection, the draft treaty focuses on both kinds of radioactive material — weapons usable material and other material which can be dangerous to life and health [22].

With all the IAEA efforts and the available instruments, regional and international, it is undoubtedly the case that in the near future, all radioactive sources, both in use and in storage, will be physically protected without much additional funding being required.

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DISCUSSION

E.I. VAPIREV (Bulgaria): The title of Mr. Ridwan's presentation contains the words "significant radioactive sources", and that of Mr. Paperiello's presentation in Topical Session 1 contained the words "high priority radioactive sources". Is the physical form of the radionuclide in a radioactive source — as it affects, for instance, dispersability or solubility — taken into account when one is deciding whether a source is significant or of high priority?

R. MESERVE (United States of America): I think that, when categorizing sources for security purposes, it will be necessary to take into account not only the radioactive properties of the radionuclide but also its physical form, for instance whether the radionuclide is a metal or a powder.

P.D. ZIMMERMAN (USA): When talking about the physical form of radioactive sources, we should bear in mind that the chemistry of all of the various radionuclides used in such sources is well known. It is therefore not unreasonable to assume that an organization like Al Qaeda could build primitive hot cells and convert radionuclides into readily dispersable or soluble forms.

Regarding Mr. Ridwan's presentation, I was very impressed with the great care that had obviously gone into the development of Indonesia's regulations. However, I wonder whether Indonesia has the resources necessary for implementing its ambitious regulatory programme.

M. RIDWAN (Indonesia): I think it has. Our Nuclear Energy Control Board has a staff of around 200 and is quite well funded. At the same time, it needs further assistance in terms of training.

K. GRYSHCHENKO (Ukraine): Which elements of the Convention on the Physical Protection of Nuclear Material are relevant to the security of radioactive sources?

M. RIDWAN (Indonesia): All nuclear facilities in Indonesia where there is nuclear material are required to comply with the provisions of the Convention, and an IPPAS mission came to the conclusion that the reviewed facilities were complying. Therefore we consider the radioactive sources at those facilities to be under adequate physical protection.

K. GRYSHCHENKO (Ukraine): What about sources that are located in other places?

M. RIDWAN (Indonesia): Our National Nuclear Energy Agency has a waste management facility to which all disused sources are supposed to be transferred by the former users. These users have to pay a fee, however, and if they do not have the necessary funds they are required to have their disused sources stored at other National Nuclear Energy Agency facilities, where they are under adequate physical protection, pending transfer to the waste management facility.

SUMMARY OF TOPICAL SESSION 2

The session was opened by Mr. Meserve, Chairman of the United States Nuclear Regulatory Commission, who in his opening remarks provided an outline of the components of an effective regulatory programme to counteract the malevolent use of high risk radioactive sources. He indicated that radiological dispersal devices could not cause large numbers of casualties but could meet the objectives of terrorists by causing panic and substantial economic consequences. Traditionally, measures had been focused on the protection of workers and the public from normal use and accidents; now the possibility of malevolent use necessitated a modification of approach.

The session comprised five presentations: Mr. McIntosh provided a review of the development of the Code of Conduct on the Safety and Security of Radioactive Sources; Mr. Biro provided an overview of the arrangements in Romania relevant to strengthening the security of radioactive sources; Mr. Dodd provided a review of draft IAEA guidance on the security of radioactive sources; Ms. Cetto provided a review of the IAEA Model Project on Upgrading Radiation Safety Infrastructure; and Mr. Ridwan provided an overview of the security arrangements for radioactive sources in Southeast Asia, with particular reference to Indonesia.

A number of underlying themes were identified in this session:

(a) The importance of a consistent and harmonized global approach to the security of radioactive sources, recognizing that sources can readily pass from one country to another;
(b) The importance of national infrastructures for the control of radioactive sources, comprising legislation, regulations, and the establishment of a regulatory authority with the appropriate authority to issue authorizations and to undertake inspections and enforcement action;
(c) The importance of defining the security elements that are necessary to combat the malevolent use of radioactive sources above and beyond those security elements necessary for the purposes of 'conventional' safety, recognizing that radioactive sources provide important benefits to individuals and society;
(d) The importance of ensuring adequate regulatory requirements throughout the life cycle of sources, including export/import controls and waste management.

The following conclusions may be drawn from the session:

(1) Following further consultations with Member States, accelerated establishment of a coherent and transparent scheme for the

categorization of radioactive sources would be useful in order to provide a graded approach to the safety and security of radioactive sources.

(2) The formulation and implementation of national plans for the management of radioactive sources throughout their life cycles should be realized.

(3) To the extent practical, standards should be developed for the design of sealed sources and associated devices that are less suitable for malevolent use (i.e. alternative technologies, less dispersable forms of radioactive sources, etc.).

(4) Arrangements for the safe and secure disposal of disused radioactive sources, including the development of disposal facilities, should be established.

(5) The formal endorsement by the IAEA Board of Governors of the Code of Conduct on the Safety and Security of Radioactive Sources, which is currently being revised, after the resolution, through the IAEA's relevant advisory mechanism, of comments made by Member States, would be useful.

(6) The Model Project on upgrading radiation safety infrastructures, now covering 88 Member States, was recognized as a powerful mechanism for assisting Member States in developing their infrastructures for the control of radioactive sources and should therefore be continued, and exploration should be undertaken into how the approach might be applied to States not Members of the IAEA.

(7) The IAEA should continue its work to clarify the additional security measures that are required in order to address the malevolent use of radioactive sources, graded according to the risk that they present.

INTERDICTING ILLICIT TRAFFICKING

(Panel Discussion 1)

Chairpersons

T. Zhantikin
Kazakhstan

R. Hoskins
IAEA

STRATEGY AND METHODS FOR DETECTION OF ILLICIT TRAFFICKING OF RADIOACTIVE MATERIAL

L. SALGÓ
Hungarian National Police Headquarters,
Budapest, Hungary
E-mail: salgol@mail.orfk.b-m.hu

Abstract

The paper presents general considerations related to the strategy and methods for the detection of illicit trafficking of radioactive material, along with a discussion of the domestic implications for Hungary and the principal components of the Hungarian strategy for detecting illicit trafficking.

1. GENERAL CONSIDERATIONS

The steady presence of illicit trafficking of radioactive materials — particularly when such materials could potentially be used in radiological weapons — might result in serious public health effects and damage to the environment. The increasing awareness of the international community of the possible consequences have prompted measures aimed to improve the control and protection of these materials at both national and facility level.

— Establishment of a comprehensive legislative and regulatory system that includes international undertakings and that takes into account the current international recommendations and standards relevant to the security of radioactive materials is the cornerstone of prevention. An additional essential requirement is the collective effort of the various law enforcement authorities.

— Threat assessments are being improved by better information exchange and refined co-operation with competent international organizations. The IAEA's Illicit Trafficking Database programme can provide particularly valuable input for evaluation of the expected trends. In some countries it might be difficult to release detailed information prior to judicial process, or to qualify a case prior to the final judgement. However, the extension of the Illicit Trafficking Database by the relevant information obtained during the judicial process might or should be considered. Source and route attribution of the smuggling can be improved substantially by advanced — including nuclear — national and international forensic capabilities.

— Initiatives to strengthen (and maybe extend) the international physical protection regime are being seriously considered. Continued efforts are required to improve the physical security of radioactive material, including an enhanced assessment of the security requirements and training. In the case of orphan sources — when the provisions of the International Basic Safety Standards issued by the IAEA are not followed — the improvement and proper implementation of the process of regaining regulatory control of the sources is of paramount importance.
— An international tagging system together with national and internal registries for radioactive materials could provide substantial help for the tracking of materials involved in illicit trafficking incidents. Some reference to the certificate of the sealed source might be a solution. However, the technical details of a feasible implementation require a wide scale discussion, and the transitional period (with the existence of the old sources) results in additional difficulties.
— Monitoring of transit is of paramount importance. Installation or modernization of a complete border monitoring system generates an important barrier on smuggling routes for illicitly trafficked radioactive material.

In addition to the international, cross-border character of the illicit trafficking in radioactive materials, the synergy of the above mentioned measures is considered as a strong argument for a comprehensive and co-operative international approach.

2. DOMESTIC IMPLICATIONS

The emergence of illicit trafficking of radioactive material in Hungary in the first half of the 1990s proved to be a serious challenge for our domestic regulatory and control system. Unauthorized receipt, provision, use, transfer or disposal of these materials poses a threat to public health and safety. In addition, since the events of 11 September 2001, threats of a possible terrorist attack involving the use of radioactive material should not be considered negligible. The cases revealed prompted efforts to provide a comprehensive response, including wider international co-operation, new legal instruments and improved technical resources. Our experience shows that in the overwhelming majority of our past cases, the radioactive material seized came from abroad, i.e. Hungary is a transit, rather than a destination, country. As a consequence, the monitoring of transit and prevention become important cornerstones of our strategy.

Hungary has a sound national control system for radioactive materials. This includes a State system for accounting and control, physical protection regulations, export–import control, regulation of transport and packaging, and radiation protection regulations in accordance with international standards. As an additional tool — in order to strengthen our national regulation and control system and to improve the efficiency of combating illicit trafficking — a Government Decree was issued in 1996 on measures related to radioactive or nuclear materials found or seized. It defines the adequate operational procedures and priorities.

Our strategy for detecting illicit trafficking in radioactive materials is based on several principal components.

— International agreements and conventions stipulate the rules of physical protection of radioactive materials and emphasize that it is important to penalize misuse and threats to misuse radioactive materials to harm the public. The penalty should be a deterrent in order to prevent the perpetration of crimes relating to unlawful trafficking in radioactive substances. In order to achieve this objective, the Hungarian Criminal Code strictly penalizes any such crime. According to the Hungarian Criminal Code, persons who participate in acts of misuse of radioactive sources or in supporting such acts are to be brought to justice. Such acts are established as felonious criminal offences in our laws and the punishment duly reflects the seriousness of such acts.
— We have a central registry for radioactive materials, including the open sources as well. Owing to its size, however, the optimization of the regular inspections required some improvement. In the near future we plan to introduce a yearly (booking) inventory taking and to support computerized communication. If an inspection — prompted by a discrepancy — confirms the absence or disappearance of some radioactive materials, the law enforcement authorities will try to regain regulatory control.
— Although nuclear materials have a privileged status concerning physical protection, we are considering the application of similar approaches (e.g. restriction/prevention of physical access) for the most dangerous radio-active materials as well. In order for the approach to be commensurate with the radiological risk that a radioactive source presents, the scheme provided in the IAEA Categorization of Radiation Sources (IAEA-TECDOC-1191) is followed.

— The role of a complete border monitoring system cannot be overemphasized. In the framework of a European Union PHARE project, and with additional support from our Ministry of Environmental Protection, a border monitoring system was established. We deployed sensitive portable monitors at 36 border crossing points in order to be able to detect heightened levels of radioactivity in a motor vehicle used in freight traffic. In addition, the officers concerned are equipped with handheld detection devices. We place emphasis on proper and regular training as well.
— With the aim of training the responsible law enforcement units and the experts of the technical support organizations, we regularly organize table-top exercises. As a common feature, the scenario of the exercises follows the provisions of the Government Decree. In addition, this scenario is complemented with some elements of the Draft Model Action Plan for Seized/Found Radioactive or Nuclear Material of the Nuclear Smuggling International Technical Working Group. We aim to organize exercises of gradually increasing complexity. In the first exercise the main emphasis was on the co-ordination of the activity of the different authorities taking part (including the verification of the communication channels). In addition, the exercise provided an opportunity for a field test of the portable equipment — received within the framework of the PHARE project — for the non-destructive assay of the samples seized. The next exercise (in 2000) was performed at a real border crossing point at Ártánd. In this case the main emphasis was on the detection of covert methods of smuggling. The smuggled enriched uranium was covered with a legal transport of a highly active radioactive source. In the third exercise (in 2002) the emphasis was on the detection of a covert way of smuggling a Pu–Be neutron source. (The previous samples were detected with γ detectors.) An additional challenge at this time was to provide an on-site estimate for the amount of the nuclear material content. We always require this step in order to be able to exclude (or recognize) a critical safety concern prior to the transport of the confiscated material.
— Intelligence activity effectively contributes to the prevention of illicit trafficking. Specialized units of intelligence services, police and border guards gather operational intelligence in order to detect illegal trafficking in radioactive materials. International co-operation in this field is very important for reducing the international character of illicit trafficking. It facilitates combating cross-border crime through intelligence activities in any place where radioactive materials are legally used. The exchange of information within the framework of international co-operation has proved to be useful in the detection of several criminal cases connected with illicit trafficking of radioactive substances.

Finally — as a practical example — the following is an interesting case that happened in Hungary. On 10 November 1994, a transport container was confiscated in Budapest that contained depleted uranium as shielding material. (All the other nuclear material confiscated in Hungary contained low enriched, natural or depleted uranium in the form of fuel pellets or rods.) The original request was for “25 kg uranium above 90%”. The smugglers were arrested. They believed that the 90% requirement related to the chemical purity. It sounds like a joke; however, it is worth while to mention that on 14 December 1994, 2.73 kg of highly enriched (87.7% ^{235}U) uranium was confiscated in Prague.

BORDER MONITORING AND CONTROL: THE EXPERIENCE OF THE CUSTOMS BODIES OF THE REPUBLIC OF BELARUS IN THE PREVENTION OF ILLICIT TRAFFICKING OF NUCLEAR AND RADIOACTIVE MATERIALS

I. AVIN
State Customs Committee of the Republic of Belarus,
Minsk, Republic of Belarus

Abstract

The paper discusses the experience of the customs bodies of the Republic of Belarus in combating illicit trafficking of nuclear and radioactive materials. There exists a real threat of unauthorized movement of radioactive materials on the territory of Belarus, because of its geographical situation. The tasks of customs bodies in the realization of border monitoring and control are presented, along with examples of illicit trafficking. The border monitoring and control equipment used by the customs bodies, international technical co-operation and the creation of an automated system of radiation control are discussed.

In September 1994 the IAEA General Conference adopted a resolution calling upon States to take all necessary measures for the prevention of illicit trafficking of nuclear and radioactive materials, and in March 1995 the IAEA Board of Governors decided that development of the programme in this area should be continued.

The Republic of Belarus has always acted in support of such activity, realizing that illicit trafficking is fraught with both the threat of spreading nuclear weapons and the potential for radiological exposure of the public.

Special importance should be given to prevention of illicit trafficking of nuclear and radioactive materials from the point of view of increasing the efficiency of measures taken by the world community in the struggle with terrorism.

Border monitoring and control is one of the components of the effort against illicit trafficking of nuclear and radioactive materials. The prevention of any goods smuggling, including smuggling of nuclear and radioactive materials, is one of the functions of customs bodies, along with serving the State treasury. For this reason, in many countries, including Belarus, customs bodies play the key role in prevention of illegal movement of nuclear and radioactive goods across State borders. Pursuant to Article 26 of the Law of the Republic of

Belarus entitled On the State Border of the Republic of Belarus, the customs bodies are entrusted with the responsibility for exercising radiation control at border checkpoints.

Belarus has no nuclear power stations and does not produce radioactive and nuclear materials, so the control over them is to a considerable extent related to the transit of such materials to Western countries. It should be noted that the border of Belarus with Ukraine, Poland and the Baltic States is an external border of the Union of Belarus and the Russian Federation and the Customs Union within the framework of the Commonwealth of Independent States. On the Customs Union Member States' territory, first of all in the Russian Federation and Kazakhstan, concentrated mining and production of nuclear and radioactive materials is conducted, part of which materials may be transported (legally or illegally) by the shortest route to the West, through the territory of Belarus and across its borders.

In addition, a considerable part of Belarus suffered from effects of the Chernobyl accident. In a number of affected areas, resettlement zones were established in which it is legally prohibited to reside. There is a danger of various radioactive wastes from neighboring countries being smuggled into and disposed of in these zones. On the other hand, cases are known in which timber, construction materials, commodities and foodstuffs were exported abroad from the contaminated areas.

A real threat of unauthorized movement of radioactive materials on the territory of Belarus derives from its geographical situation:

— Two out of ten major trans-European passages cross the territory of Belarus.
— The recently closed Chernobyl nuclear power station, which is at present a dangerous place containing new and waste nuclear fuel, as well as radioactive materials and equipment, is situated in immediate proximity to Belarus.

The task of customs bodies in the realization of border monitoring and control consists in detecting and preventing unauthorized movements of radioactive materials through the customs border.

In the period from 1996 until February 2003, 26 cases of detention of cargo with an increased level of radioactivity were registered on the State borders of Belarus. The cargo detained came from Russia (6 cases), Belarus (2), Germany (2), Ukraine (2), Cyprus, Italy, Kazakhstan, Lithuania and Poland, and basically consisted of scrap iron and waste metals contaminated with radioactivity (11 of the 26 cases). There were 9 cases of unlawful movement through the border of radioactive materials and sources intended for industrial use. The following attempts at movement of cargo with increased radioactivity levels were revealed:

— Transit movement through the territory of Belarus (18 cases, 10 of them in a western direction);
— Export from Belarus (5 cases);
— Import to Belarus (3 cases).

There have been some cases of detection on the State territory of illegally imported radioactive materials intended for further export abroad. For example, in the area of one of the frontier checkpoints on the border with Lithuania, four spherical containers with ^{137}Cs with a radiation level of 20 μSv/h were discovered.

In February 2003 in Bobruisk, persons trying to sell two standard factory containers of ^{137}Cs, imported into Belarus from Russia, were detained.

The experience of the customs bodies of Belarus and Russia shows that the use of stationary installations — 'portal monitors'— is the most effective element for border monitoring and control. These monitors are installed at strategically important checkpoints and automatically produce an alarm signal in the event of movement of radioactive materials through borders. Belarus is one of the first States in Europe to begin the installation of portal monitors on borders.

The first portal monitors — BAPF-15 monitors manufactured by the French firm Nardeux — were installed in Belarus in 1993 at two border checkpoints in Brest, on the border with Poland. In 1996 the stationary systems Ludlum 3523 were installed on the border with Lithuania and are still in use. In 2003 some border checkpoints on the borders with Poland, Lithuania and Ukraine were equipped with portal transport monitors manufactured by the Byelorussian enterprise Polimaster

Since 1996 border monitoring and control is being carried out at 8 of the 32 road customs checkpoints.

It should be noted that in 2001–2002 outdated equipment, including BAPF-15 monitors, at some customs checkpoints was replaced by modern systems having γ and neutron detectors and satisfying other requirements of the Illicit Trafficking and Radiation Assessment Programme (ITRAP).

At present only 1 out of 19 railway customs checkpoints is equipped with portal radiation monitors. Unfortunately, there are no luggage portal monitors in establishments of the international post exchange and at the Minsk-2 international airport .

In connection with the high cost of stationary systems, only large customs checkpoints with intensive traffic are equipped with them. The primary radiological control at other customs checkpoints is carried out with the use of portable search monitors.

Customs bodies of Belarus employ search devices manufactured by the Byelorussian firm Polimaster and by the United States companies Ludlum and Gateman, supplied to customs offices within the framework of programmes of technical assistance. Unfortunately, the devices of foreign production are not certified in Belarus and naturally have no service support in our country, which results in some problems when the devices need repair.

In spite of these difficulties, the State Customs Committee of the Republic of Belarus makes every effort to solve the problem of equipping customs bodies with radiation control devices, for example at the expense of facilities selected from the State budget for the maintenance of customs bodies, and within the framework of international technical co-operation.

In 2001–2002, within the framework of the Technical Co-operation programme of the IAEA, an automated system for customs control of the movement of nuclear and radioactive materials through the customs border of Belarus in Brest was created at two customs checkpoints — one for road vehicles and one for trains — through which cargo is transported.

The automated control system provides automated monitoring and detection of any object giving off radiation, registration of its parameters and a video image of the object, and transfers the information onto the computer of the workplace.

It is necessary especially to note that, thanks to IAEA Technical Co-operation, the first railway checkpoint in Belarus has been established that is equipped with modern radiation control devices, including portal monitors. The national project included in the IAEA Technical Co-operation programme is not yet completed, but the equipment is used in a working mode and we already have the first results: detection of two cases of cargo movement by rail of chemicals containing radionuclides without appropriate permit documents.

The principles and methods of automated radiation control at border customs checkpoints equipped with modern stationary monitors are planned to be developed within the IAEA Technical Co-operation programme in 2003–2004. The automated system for radiation control includes radiation monitors at specific transit points, videomonitoring of automated registration, and automated processing and transfer of information to the operating personnel of the transit points. The incorporation of the automated systems at different transit points into an integrated network is also planned.

Thus a centralized automated system of collection, processing and transfer of data will be created, uniting all border customs checkpoints where radiation monitors are installed in a uniform network, with transfer of the information to the State Customs Committee of the Republic of Belarus. Other customs checkpoints will be connected to this network as they are equipped with portal monitors and other necessary devices.

A correct response in cases of detection of unauthorized movement of nuclear and radioactive materials and the identification of radioactive materials are very important to the realization of border monitoring and control.

The State Customs Committee of the Republic of Belarus makes efforts to prevent the illicit trafficking of nuclear and radioactive materials, in close interaction with the Ministry of Public Health Services, the Ministry for Extreme Situations, the State Border Committee, the Committee of State Security and other relevant departments of the Government of Belarus.

Nevertheless, the order of interaction and response of these departments at present is not sufficiently elaborated. The development of a model plan of response by the relevant departments for cases of detection of radioactive sources in illegal circulation is required.

Another problem requiring resolution is the absence in the State of an officially accredited national expert laboratory for the identification of radionuclides.

The experience of the staff is of great importance in implementing the procedure of customs release and control of nuclear and radioactive materials. In this connection the issues of personnel training and of raising the level of skill of the personnel are not less important problems for us.

We consider as very important the participation of Belarus customs officials in the international seminars on the struggle against illicit trafficking of nuclear and radioactive materials which have been held in Vienna by the IAEA together with the World Customs Organization and the International Criminal Police Organization, and also in the training courses organized by the IAEA together with the Russian Customs Academy.

In recent years much has been achieved, owing in part to the active technical support of the IAEA, but the world situation demands still greater measures for the prevention of illicit trafficking of radioactive sources. Therefore the further development of international technical co-operation with the IAEA, and also development of contacts on a bilateral and multilateral basis, are of great importance.

The further increase of efficiency of border monitoring and control could be promoted by use at strategically important checkpoints of scanning systems for container and vehicle inspection that allow examination of large containers, for example truck trailers, without opening them. These systems use linear electron accelerators or γ ray sources for the scanning of metal containers and trailers. We consider that the IAEA could serve a role in the introduction of these new high technology systems into the practice of border monitoring and control.

CAPABILITIES OF DETECTION EQUIPMENT AND DEVELOPMENT NEEDS

C. SCHMITZER
Health Physics Division,
ARC Seibersdorf Research,
Seibersdorf, Austria
E-mail: chris.schmitzer@arcs.ac.at

Abstract

The most comprehensive recent study on the performance of commercially available monitoring equipment was performed by the Austrian Research Center in close co-operation with the IAEA. This Illicit Trafficking Radiation Detection Assessment Programme (ITRAP) was made possible by the participation of more than 20 international manufacturers of stationary and mobile monitoring equipment. The study also highlighted strong and less strong points of current equipment. Attention was paid to the complete detection and response process, considering the deployment by front-line officers at checkpoints (a field test was undertaken at the Hungarian–Austrian border crossing at Nickelsdorf). Again, practical experience showed possible consequences for the actual implementation of such a monitoring programme. Technically, a number of factors still need to be addressed, first and foremost in the area of handheld radionuclide identifiers, small instruments allowing identification of radionuclides in the field. The paper presents an overview of the results of the ITRAP study in terms of detection capability and deployment considerations, problems encountered and improvement potential, and a discussion centred on improvement potential and development needs regarding the implementation of a monitoring programme.

1. INTRODUCTION

Illicit trafficking and inadvertent movement of nuclear and other radioactive materials are not new phenomena. However, concern about such activities has increased remarkably in the last decade. Although the number of such incidents has risen, the overall extent of the problem is not restricted to Europe or to nuclear proliferation. A few per cent of these incidents involve ‘special nuclear materials’, which may be used for nuclear weapons and therefore cause a threat of nuclear proliferation. The vast majority of these incidents, however, involve radioactive sources, or low enriched, natural or depleted uranium, which are not usable for weapons. There have been instances in which loss of control over radioactive materials has led to serious, even fatal, consequences to persons. Examples include the unintentional incorporation of radioactive materials into recycled steel, the recovery of lost radioactive sources by unsuspecting individuals and the deliberate purloining of radioactive material.

A great deal of information is already available, partly presented during this conference, based on studies, exercises, laboratory and field tests, and publications in the open literature discussing these problems. Specific challenges are associated with counterstrategies in this field, which will be discussed in greater depth in the later sections of this paper. One of the sources drawn upon extensively was the Illicit Trafficking Radiation Detection Assessment Programme (ITRAP) — financed by the Austrian Government and executed by the Austrian Research Center in close co-operation with the IAEA, the International Criminal Police Organization (ICPO-Interpol) and the World Customs Organization (WCO) — aimed at finding international consensus on specifications for detection equipment and instrumentation as well as verification of such specifications in laboratory tests and field installations. Under the umbrella of the pilot project, 23 international companies participated in the study and many of them devised improvements of their monitoring equipment.

Specific sessions of the present conference target various issues related to minimizing the risk of proliferation of nuclear materials as well as the risk of loss of control of radioactive substances, including ‘defence in depth’ strategies. However, once preventive measures have been circumvented and when loss of control over nuclear or other radioactive substances must be suspected, the focus changes to various detection techniques in order to regain control and reapply regulatory authority over these substances. Unauthorized possession, application, trading or transport of nuclear or other radioactive substances constitutes a case of illicit trafficking or inadvertent movement, which is of concern not only to the regulatory authorities but to the many institutions involved in the process of regaining control, and ultimately to the general public.

Combating trafficking in nuclear or other radioactive material — both illicit and inadvertent — is a multifaceted endeavour that entails much more than just the application of radiation measuring instrumentation. However, this paper addresses primarily the technological challenges associated with this undertaking, on the basis of lessons learned from the pilot study, considering also challenges beyond the technological arena which affect the overall result.

In line with standard IAEA practice, in the following text the term ‘radioactive material or substance’ is used to refer to both radioactive sources — natural or anthropogenic radioactive substances — and fissile materials, specifically special nuclear material (SNM).

2. FRAMEWORK

Combating the trafficking of radioactive material, perceived as a technological challenge, is not an issue that can be addressed independently of the proper framework of activities associated with exercising control over radioactive materials — as has already been discussed at previous conferences (for example at the Dijon conference in 1998 [1] and at the Stockholm conference in 2001 [2]). Individual situations and specific circumstances will call for tailored solutions, adjusting both the technical capabilities of the instruments employed and their application in the procedure of identifying a possible case of illicit trafficking or inadvertent movement. These decisions will be governed by an assessment of the threat potential (quantitatively as well as with respect to the characteristic assumptions for the probable target incidents), by the expertise and training level of the institutions involved (the human 'detectors') and by the specific scenarios to be considered (e.g. scrap metal monitoring versus airport passenger scanning, nuclear facility perimeter monitoring versus fast scanning at borders). The following sections will first outline a few of these considerations, then focus on general technical issues of instruments and lessons learned, and finally attempt to derive general considerations addressing technological challenges.

We are primarily concerned with the capabilities of technical detection methodology, the ensuing actions once an alarm has been generated, and the associated requirements imposed on instrumentation and infrastructure. A most important detail not discussed here is the design basis threat, identifying possible threat potentials (origin of the problem) and probable scenarios and targets (possible consequences of the problem). Such scenarios will have to be carefully analysed with a view to given installations, working procedures, diversion potentials and overall detriment, and will have to be weighed against probability of occurrence and, of course, overall cost.

The findings of such a careful analysis will therefore define what actually constitutes a threat, the relevant countermeasures to be taken with associated target specifications, and the technological (and other) challenges resulting therefrom. The general concern is to avoid any hazard to health and environment arising from the radioactive substances illicitly or inadvertently trafficked and to detect 'small' quantities of SNM as part of non-proliferation efforts. Radioactive substances associated with scrap metal (concealed sources) are usually not easy to detect and, though posing the largest commercial risk, are generally excluded from consideration in border control environments, unless the source activity is so high as to constitute a health hazard.

The IAEA database on verified illicit trafficking incidents [3] might lead to the assumption that the number of incidents involving fissile material has significantly decreased (in absolute and relative figures) compared with incidents involving radioactive sources. A discussion of this evidence will not be attempted here; however, within the threat and target analysis mentioned above, a detailed understanding of the source of the problem must be formed as well as a clear understanding regarding the design based efficiency of the threat aversion methods employed. For the detection process, technical specifications and associated challenges will result from these decisions. For example, in some situations the detection of SNM will have priority, and equipment specification and selection will reflect that, whereas in other cases the detection of radioactive sources in scrap metal might be the relevant target.

2.1. Instrumentation

A large variety of instruments are available on the market and even more are being employed by dedicated institutions for specific purposes. A very brief discussion of instruments and associated capabilities will be presented. Data sheets of instruments having undergone rigorous testing under ITRAP are further described in the Annex of the official ITRAP report [4].

(a) *Pocket size instruments (radiation pagers, electronic dosimeters):* The models of this type of instrument should be easy to use, even by non-specialized staff. Their purpose is to allow a quick and qualitative assessment of suspect materials. They have to be battery powered and must be shock and water resistant. There also should be low requirements for maintenance and calibration. Typically these instruments are autoranging and serve as alarm indicators by audio, visual or vibrational alert. The high sensitivity required to detect small quantities of radioactive material usually requires solid state detectors and rules out classic Geiger–Müller tubes. With non-proliferation concerns rising, even neutron sensitive small devices are being developed.

(b) *Handheld instruments:* Such instruments are used for localization and identification. They are generally more bulky than pocket sized instruments and exhibit more features. With the requirement for increased sensitivity, more complex evaluation procedures are required, leading to the inclusion of spectroscopic evaluation techniques that yield information on the type of radioisotope (radionuclide identifiers). However, the use of such instruments is more demanding and requires a higher degree of training. Under the guidelines of the response strategy, such instruments are typically employed when a detection has been made initially and more detailed characterization of the material detected is desirable, specifically when detailed localization or identification is required. A number of commercially available instruments have been and are being tested, and the potential for improvement still seems to exist.

(c) *Mobile systems:* The distinction between handheld and mobile systems is somewhat diffuse. Mobile systems are regarded as being more complex and bulky, and allow measurements at even higher sensitivity from mobile platforms, such as specially adapted cars, helicopters or loading cranes. Their area of application comprises, for example, concealed searches within the interior of a country, large area scanning or loading dock situations. Their capabilities are usually tailored to meet the needs of the specific situation, for example with respect to sensitivity, type of radiation detected, size and cost. Similarly, various methods of data processing and transmission are employed either locally or remotely.

(d) *Portal type instruments:* Such instruments are designed to be located at checkpoints at borders or at the boundaries of nuclear facilities or other institutions requiring monitoring (e.g. the scrap metal entry to steelworks). Monitors are often designed to be similar to a gate, causing the traffic to flow through the gate only. They should allow monitoring of the flow of goods or people at the closest distance possible. The control and display units are located in a separate place and usually feature some form of tamper protection. Operation necessitates only a low level of training, concentrating on first-line response and functional checking. Ideally, the flow of goods, baggage, persons or vehicles may be monitored at considerable speed without obstruction at low false alarm rates. The typical output is the alarm signal providing a go/no-go decision.

(e) *Special instruments:* According to the complexity of a specific case, more elaborate equipment may be employed and more specialized personnel involved in characterizing, isolating and regaining control of an illicitly trafficked radioactive substance. Though some field laboratory type capabilities have been introduced with recent instruments, allowing complex in situ identification techniques (e.g. high resolution γ spectroscopy by means of high purity Ge detectors), certain problems will still have to be referred to laboratories and their highly specialized staff and equipment. These special instruments, though sometimes necessary in the context of illicit trafficking, will not be discussed further in this paper.

2.2. Instrument capability versus agreed intervention level

‘Detection’ is defined in IAEA-TECDOC-1312 [5] as a “conclusion based on measurement and the interpretation of the results”. Detection therefore consists of two important processes, the measurement of elevated radiation levels and the interpretation of these readings to constitute a case of illicit trafficking or inadvertent movement, screening out other possible trigger events.

One of the most important properties of any instrument in the measurement process is its detection limit. The detection limit is a value derived from laboratory tests of instrument performance, from controlled field tests or — less reliably — from statistical calculations, defining the smallest signal where reliable detection can be made. The 'signal' depends on the nature of the instrument and may comprise the indication of a specific activity, a dose rate, a relative reading or an alarm. However, this issue is further complicated by the naturally occurring radionuclides in the environment and the statistics inherent in the process of detecting radiation. Any criterion (or selected detection threshold) for elevated radiation intensity has to take into account the spatially and temporally varying background and the statistics of detection.

Under most scenarios, the result of a detection beyond a previously established alarm threshold will result in some kind of alarm indication and cause further action in order to interpret the event. Though individual response plans may prescribe specific routes of action, the general tendency will be to investigate the validity of the alarm and gather more information on this newly established 'case'. Therefore it has been agreed to call the previously established alarm threshold — which causes an alarm — the 'investigation level'. Elevated readings below the investigation level do not necessarily rule out the presence of a radioactive material in a given situation; under pre-established guidelines such readings simply do not give rise to further investigation. Readings exceeding the investigation level do not necessarily indicate a case of illicit trafficking or inadvertent movement; however, they need to be further investigated.

For the ITRAP project, an investigation level of 100 nSv/h above background was adopted by the consensus of international experts. This level is on the order of the natural background radiation itself.

The agreement on a specific investigation level therefore is a decision based on national policy. It is derived from political and expert consensus, similar to other threshold settings (e.g. speed limit), and is not primarily a detector related quantity. This level should be high enough to allow detection not to be adversely affected by variations in natural background radiation, or by low levels of radiation originating from exempt practices or cleared radioactive materials in low quantities. Whatever the choice, it must be ascertained that the detection limit of the instruments used is below the selected investigation level. By the consensus of experts, minimum requirements for instruments were derived and have been compiled in IAEA-TECDOC-1312 [5].

However, many natural or anthropogenic radionuclides will legally appear in quantities causing an alarm by exceeding the chosen investigation level. These may result from processes involving radioactive substances exempted from regulatory control or from substances excluded up to a certain activity concentration or total content. The various causes of alarms will be analysed in the next section.

2.3. Alarms

As perceived from the instrument, three types of alarm may be differentiated:

(a) The true alarm is caused by an amount of radioactive material passing the detector. The signal processed by the instrument indicates radioactivity beyond the pre-established investigation level. This may be caused by legal shipments, inadvertent movement or illicit trafficking and needs further investigation. True alarms are quantified by the detection probability.
(b) The false alarm is caused by no radioactive material associated with goods or people passing the detector. It may be caused by variations in natural background, by poor statistics, by instrument malfunction or by unknown reasons. The quantitative measure is the false alarm rate, usually specified as fraction of time or fraction of passages through the gate.
(c) The missed alarm is not an alarm situation; that is, the instrument should have sounded an alarm, but there was none. The specification on detection probability (the complementary figure to missed alarm rate) basically involves a statistical treatment, which allows equipment operating fully within specifications a certain probability of missing an alarm. Missed alarms and false alarms are closely correlated; improving one without compromising the other usually leads to significant cost increases.

However, even more important is the perspective of the user, the first responder, whose responsibilities require some kind of investigation once the alarm has gone off. In a no-alarm situation, there is no immediate response required unless other observations arouse suspicion.

(1) A false alarm situation has to be verified as false by repeating the detection process or employing additional means such as handheld instruments in order to verify the alarm as true or false. This may be time consuming and therefore the false alarm rate is a critical instrument parameter.

(2) A true alarm may represent an innocent alarm, caused by movements of radioactive substances which do not constitute a case of illicit trafficking. Legal transports of radioactive materials may also trigger an alarm; however, identification should be straightforward pursuant to transport regulations. Innocent alarms are typically caused by naturally occurring radioactive substances such as ^{40}K or low quantities of U or Th. Likewise, medical radionuclides administered to patients in nuclear medicine have frequently been known to trigger alarms. Evaluations of border type scenarios have shown most alarms (up to 80% in specific situations) to be caused by natural radionuclides, thus creating a major nuisance for the operating personnel (hence the term nuisance alarm may also be found).

(3) An alarm identified as neither false nor innocent will have been caused by either inadvertent or illegal activities involving radioactive substances and usually triggers a predetermined response mechanism.

2.4. Alarm response

In connection with the technological challenges in the detection process, the specifics of the alarm response will be outlined briefly. In line with the chosen scenarios, the instruments and response strategy in a specific setting must enable the detection process to achieve its goal, namely to ascertain that an attempt at illicit trafficking or inadvertent movement has occurred. As already outlined above, a logical first action will be to establish what kind of alarm situation has evolved: true, false or innocent (the missed alarm will go undetected).

(a) In the case of an innocent alarm, actual radioisotopes or at least classes of radioisotopes must be identified (e.g. medical, natural). Though some insights may be gained from shipping papers or interviews, the frequent occurrence of such alarms eventually leads to extended requirements for the instruments to enable such differentiation to be made on the spot without involving cumbersome analysis or a laboratory procedure. The specifics of the environment and associated constraints must be considered, e.g. the lack of time in border type situations.

(b) Once a true alarm has been verified and the conclusion based on measurement and interpretation has been drawn that a case of illicit trafficking or inadvertent movement exists, a general response strategy will be to assess the hazard of the situation, possibly to isolate the shipment or person and to conduct further measurements to pinpoint the exact location or source of the problem. At some point during this process the front-line officer who detected the case will hand over responsibility to a specifically trained or more experienced 'responder' or to even more specialized institutions, depending on the complexity of the case and other factors. This strategy is defined specifically in the respective response plans.

3. INSTRUMENT ASSESSMENT PROGRAMME AND LESSONS LEARNED

3.1. Objectives of the study

An important element of the ITRAP pilot study was the harmonized establishment of a detection threshold for practical implementation at borders or similar checkpoints, the investigation level. However, equally important was the verification of agreed specifications in controlled laboratory conditions and in realistic operating environments (field tests). All crucial parameters, e.g. the false alarm rate, were verified by a significant testing effort as compared with approaches based on statistical calculations only.

Apart from initial screening of equipment specifications to determine their basic compatibility with previously established guidelines and specifications, the pilot project consisted of a laboratory test and a field test. The objective of the laboratory test was to determine critical operating parameters (e.g. alarm probability and false alarm rate) under strictly reproducible conditions, eliminating as far as possible other confounding factors in the laboratory evaluation. Close to 200 000 tests were performed on most stationary instruments alone to verify these parameters. With this limited set of operational characteristics forming only part of the overall performance properties, a field test under conditions that were as realistic as possible was undertaken at the Austrian–Hungarian border at Nickelsdorf, this being the busiest road border crossing between the European Community and its eastern neighbouring countries.

3.2. Overview

Details of the assessment programme are found elsewhere [4, 6]. Specific scenarios have been analysed [7] and overviews have been presented, for example at the IAEA conference in Stockholm in 2001 [8]. The core of the testing programme was focused on the radiological parameters sensitivity (detection probability) and false alarm rate with their associated confidence levels, as well as on operational usability under realistic border monitoring conditions. Manufacturers of commercial off-the-shelf equipment were invited to participate in the testing programme, and without their dedicated support this study would not have become a success. The range of equipment included small devices (pagers and handhelds), radionuclide identifiers and stationary monitoring gates.

3.3. Alarm probability

3.3.1. Statistics

Detection can only be accomplished with a certain probability at a specific confidence level. For instance, a specific source may be detected in 4 out of 5 passes (80%) at a confidence level of (typically) 95%, signifying that the system may perform even worse than 80% detection probability in rare cases. Manufacturers, testing laboratories and field tests may specify the results at different confidence levels or for different detection probabilities, which makes them difficult to compare, not only for persons untrained in statistics. Consequently, even after wise choices have been made regarding the alarm threshold and in selecting the proper equipment, further investigation is required once the alarm sounds.

3.3.2. Detection probability

Los Alamos National Laboratory (LANL) has published a compilation of standards from the American Society for Testing and Materials (ASTM) that are applicable for certain monitoring applications [9]. There are also a number of excellent evaluations and reviews available from LANL on the subject of SNM monitoring [10, 11]. For its evaluation and testing procedures, LANL has adopted a detection probability of 50% at 95% confidence level. This has a significant impact on the overall testing effort. In the ITRAP pilot study, the distinction between instrument alarm threshold and nominal alarm threshold (or chosen investigation level) was one of the lessons learned (for further details, see, for example, Ref. [12]). These settings are identical if and only if a detection probability of 50% has been chosen. For all other settings the specific distribution function has to be considered. However, statistics play a further trick. Let us assume that a detection probability of 95% for a threshold setting of X is established. For signals somewhat smaller but close to X there will also be a significant detection probability (<95%), falling away quickly the more the signal becomes less than X. This may be the source of numerous innocent alarms if elevated radiation intensities are caused by the presence of naturally occurring radioactive substances, even below the threshold value X. However, this is not a false alarm but a proper instrument response.

For testing purposes, specifications must be reproducible as far as possible for the systems under test. For deployment under real life conditions, other considerations (robustness, ease of operation) might become more important, for example operation with minimal nuisance alarms, i.e. not too many alarms from innocent causes.

3.3.3. False alarm rate

For equipment intended to be operated by trained personnel (being non-experts in radiation instrumentation), the false alarm rate is of crucial importance. During the ITRAP project, a requirement was adopted of not more than one false alarm per 10 000 passages (10^{-4}). On the basis of a throughput of 5000 to 10 000 cars per day at the field test site under consideration, this seemed reasonable. From background count rate monitoring, initial instrument settings were derived to comply with this criterion. Most systems failed initially. It may be assumed that a theoretical treatment based on idealized statistics did not take into account the spurious effects intrinsic to the detection process or the averaging algorithms within the instruments. Especially the combined requirement of setting the instrument alarm threshold safely beyond background fluctuations (approximately 4σ corresponds to the 10^{-4} requirement) and maintaining the 99.9% detection probability at the nominal alarm level proved to be difficult.

In order to qualify, the nominal alarm level would have to be at least 7σ above average background and the instrument alarm threshold approximately 4σ. This holds true for idealized (Gaussian) statistics; real world systems would generally perform worse than that.

3.4. Response

Response to an alarm indication and proper measures to verify the alarm to be true and in fact caused by illicit trafficking or inadvertent movement are most important, as discussed in Section 2.4. An important finding during the ITRAP study was that the legal basis for response also needs careful attention. In many countries the responsibility for maintaining safety at the border may be shared among different organizations or executive bodies (border police, customs guards, the military, etc.). The legal basis for intervention in the event of an alarm delayed the field test part of the study for a considerable time, until a consensus could be found on the responsibilities and legal umbrella among the entities concerned. However, after these difficulties were overcome, a second element of concern involved the officers at the border themselves. Initially a high percentage of alarms remained unattended to (almost 50% for the truck lane, 35% for the bus lane). Careful analysis showed that the handheld equipment to facilitate searches and the general experience of the border personnel in this field did not provide adequate expertise for them to embark on possibly challenging or offensive interrogations. This was overcome by a second level training programme specifically addressing the requirements of operational response and the associated procedures in localizing sources and asking the right questions. The IAEA TECDOC on response [13] is based on practical experience and allows the structuring of tailored response procedures.

3.5. Training and support

As was mentioned above, training was an important element in obtaining overall results. Training had to address, inter alia, the basic physical properties of radiation and shielding, an understanding of the dangers (or lack thereof) of ionizing radiation, measures of self-protection, and natural and artificial radioactivity. After the first training courses had been administered, a second course of training had to be implemented to overcome problems in operational response and allow a more practical and procedure oriented approach. However, the most important lesson was that expert support could not be neglected. The frequent occurrence of natural radioactive substances and the high rate of innocent alarms led to a strong need for expert availability for consultancy in problematic cases. To comply with this need in an economical way, telephone support was implemented by means of expert availability via a dedicated hot line. This was further improved by remote access to monitoring system data via a mobile telephone link, to allow experts remote analysis of the case under consideration. This helped not only to establish a common language between officers and experts, but also led to much greater confidence on the part of the officers handling the cases in following the response procedures, because for problematic decisions they could always turn to an expert. This service was consequently established on a 24 hour basis, 7 days a week.

3.6. Restrictions

As has been pointed out above, scrap metal imposes the most stringent requirement regarding detection sensitivity. Publications by the Institute of Scrap Recycling Industries [14] recommend a minimum detectable amount of activity of ^{137}Cs, shielded to allow a surface dose rate on the container of 10 μSv/h, buried at least 1 m in loose iron scrap. The effective increase in dose rate at the outside of the vehicle based on these assumptions is a mere 6 nSv/h, under background conditions of typically 100–300 nSv/h. This constitutes an increase over the background radiation level of 2–6%, depending on the ambient level. For comparison, monitoring gates for SNM are set to approximately 4% above background level. Investigation levels recommended in the IAEA TECDOC on detection [5] have been established in the range of 100 nSv/h above standard background levels.

It is obvious that under standard border conditions, monitoring for radioactivity in scrap metal is not feasible. Large or unshielded sources constituting a health hazard to the general public will be found; however, shielded sources will require much longer measuring times or simply the unloading of the shipment. Thus the scrap metal problem was excluded from consideration in the context of the ITRAP pilot project.

Similarly, monitoring for gram quantities of fissile materials, namely Pu and highly enriched uranium (HEU), requires extremely high detection sensitivities. Since the γ signatures of certain Pu isotopes are very weak, SNM monitoring is often complemented by neutron detection techniques. As mentioned in Section 3.3.2, LANL has addressed this problem in great depth and published a number of excellent overviews in this area [9–11]. The newest category of personnel monitors achieve a detection capability for Pu on the order of fractions of a gram (solid sphere).

Since the radioisotopes being searched for and the geometries are usually well defined, the detection limit is generally specified as activity or mass of SNM. Searching for fissile materials usually requires more stringent and elaborate monitoring procedures than the procedures contemplated in the pilot study. In the study, the issue of smuggling of fissile material could not be disregarded, owing to the implications in the context of non-proliferation efforts. On the other hand, cost considerations and throughput concerns were raised. This led to a requirement for neutron detection capability along with the basic γ channel of traditional monitoring equipment; however, the detection limit was relaxed by orders of magnitude as compared with monitors deployed for perimeter monitoring of nuclear facilities. This was considered an approach commensurate with the threat potential from both fissile materials and orphan sources, and with corresponding cost implications.

4. CHALLENGES AND DEVELOPMENT NEEDS

Though this paper addresses the topic of instrument capabilities and associated development needs, a brief diversion to other challenges in this field will be excused.

The planning stage contains most of the challenges that will ultimately determine the success or failure of the chosen approach. The threat and scenario analysis will result in technical specifications considered necessary or desirable to fulfil the detection purpose. Important considerations here are:

— Design basis threat analysis;
— Target and scenario analysis;
— Kind of material to be primarily detected (sources or SNM);
— Operating environment (border crossing, checkpoint, perimeter, concealed operations, etc.);
— Response strategy.

The last item deserves special attention. Virtually all system implementations contain technical equipment, strategy components and human interaction. The response strategy relies most heavily on the human detector, usually the front-line officer. Optimal system performance necessitates not only correctly specified instruments working properly, but also adequately trained officers and an environment supportive of their work. A high false alarm rate will not be considered motivating, likewise a lack of access to crucial information when needed will pose a stumbling block. The spectrum of instruments employed will have to be fit for the purpose, requiring the design of a human–instrument interface commensurate with the training level in the field. This leads to the subject of technical challenges.

4.1. Technical challenges

We will restrict ourselves to typical applications associated with the problems of illicit trafficking or inadvertent movement, disregarding a host of other potentially interesting techniques and systems.

4.1.1. Detection principles

A radiation detector converts information from γ and/or neutron radiation into electrical pulses, thus allowing computation of various properties associated with the radiation received. Usually solid state detectors are involved (scintillation type detectors), since they yield more information per unit detector volume than, for example, gas filled devices (Geiger–Müller tubes, ionization chambers). Almost all models are microprocessor controlled, allowing the presentation of the desired result in the most appropriate form. Examples would be a simple warning device on the one hand, yielding as the result basically yes/no information, and on the other hand, spectroscopic equipment yielding a complex spectrum for radioisotope identification purposes.

Specific challenges are associated with the type of material to be detected (SNM is extremely difficult to detect by γ sensitive equipment alone), the magnitude of the signal (which may suffer through heavy shielding) and the signal to background ratio (with all its problems of background suppression by the object under test itself).

4.1.2. Detector output and signal processing

Alarm devices pose a specific challenge both for specification of technical parameters and for verification through testing. Contrary to most measuring devices, alarm systems (e.g. most portals) provide as their main output a yes/no signal only. This alarm signal is associated with a specific probability. Other devices (e.g. radiation pagers) exhibit a relative indication, while still other instruments provide detailed information under strict tolerance specifications.

The availability of high powered microprocessors has made complex algorithms possible to the extent that system behaviour is sometimes difficult to interpret. Let us take, for example, automatic background compensation. This is a widely known and fairly simple procedure. Many instruments take background readings upon power-up and store this reference value as the ambient background. Consequently, instruments must be powered up under ambient background conditions; otherwise erroneous operation may ensue. Other systems try to track temporal variations in background (e.g. unoccupied periods for portal type systems). All these algorithms work on specific assumptions, often unknown to the user, with the overall output dependent on the applicability of the operating assumptions. This might give rise to questionable results. More complex examples would be compensation for background suppression by a vehicle or compensation for elevated readings from natural radioisotopes. Generalizations regarding an optimum approach do not come easily.

The next section will deal with the interface with the user and considerations regarding complexity. Generally, as the user interface is simplified, more complex algorithms are applied internally. This might make it tempting to place more of the burden of interpretation of results on the instrument itself. However, a user must be cautioned that complex instruments are still performing very complex tasks internally that might produce errors if not kept within a complex operating envelope of preconceived assumptions. We all know this problem — we all have our own experiences with similar behaviour by our personal computers.

4.1.3. Human–instrument interface

This section addresses both the user inputs required to obtain meaningful results and the representation of these results presented to the user. Generally all instruments should be designed as much as possible with a simple if not fully automated mode, allowing use by non-specialists. Ideally this would be just the on/off switch. Some instruments require so little power that one battery lasts for months, abolishing the need for even an on/off switch. However, if more functions are required of one instrument or more complex tasks (e.g. identifiers), this often results in a complicated instrument. Engineering of the user interface to make it as simple as possible thus becomes a major technological challenge.

Similarly, instrument output can be presented in simple or rather complex terms. Though agreement has been established internationally on the unit of measurement for radiation, relative information may be found more useful for a front-line officer not necessarily well experienced in radiation physics. A number of instruments therefore feature a relative scale (e.g. 0 to 9) with simple instructions associated with each indication (e.g. "if reading is 9, retreat until reading falls below 9"). Hence the display resembles a relative, often logarithmic indication of intensity or an audible signal varying in frequency, where understanding is intuitive.

A balance has to be found between the amount of information required and the necessary skills of interpretation. A dose rate reading to five decimal places will not profit a front-line officer. Again, this problem becomes a major challenge with identification equipment, where the 'traditional' output would be a γ spectrum — of little use except for the very experienced. Elaborate software is required to interpret the raw data — an expert system — to deliver meaningful and easily digestible information such as 'medical isotope'. The challenges here are not only software related. The gap between complex information and the non-expert user has to be bridged, which will require creative solutions.

4.1.4. Radionuclide identifiers

There have been many new developments in the context of border monitoring. Within the pilot study, the need has been highlighted to identify or at least classify radionuclides as part of the response procedure. Handheld radionuclide identifiers that have recently become available were therefore evaluated. It was seen that a large development effort is still required to provide efficient instruments for non-experts under field conditions. Currently the International Electrotechnical Commission (IEC) is working to standardize such instruments. Likewise, the problem of signal deterioration caused by shielding effects will have to be addressed in more detail. Instruments based on CdZnTe detectors seem to be promising candidates [15].

For these identifiers, large challenges have to be addressed. The user interface and data presentation have to be commensurate with the skills of the user. The reliability of the analysis under field conditions must be high to allow an appropriate response (without apologies afterwards). Ergonomic operation, ruggedness, autocalibration, temperature stabilization — all belong in this category. However, there is a ‘simple’ technical challenge as well: the degradation of spectral lines through shielding. Cobalt-60 may be identified as ^{137}Cs behind solid lead shielding. Though the problem may be stated easily, there is no simple answer. Elaborate simulations making assumptions on shielding geometry have been investigated, as well as inventories of ‘standard shielding containers’.

4.1.5. Co-ordinated research projects

The IAEA maintains a number of projects to stimulate co-operative research for pressing issues. One of these is the co-ordinated research project on Improvement of Technical Measures to Detect and Respond to Illicit Trafficking of Nuclear and Other Radioactive Materials, which has the following goals:

- To improve the detection capability and performance of handheld and portable isotope measurement devices, including the technical and functional specifications for such devices;
- To standardize procedures to examine suspicious packages and to assess the hazard of confiscated material;
- To develop recommendations and guidelines for establishing a system to provide nuclear forensics support to Member States for the characterization of seized nuclear material.

4.2. Other challenges

4.2.1. Standardization

The dose rate measured in Sv/h (or Gy/h) is the chosen unit of radiation intensity. A specific dose rate value was also selected as the defining criterion for setting the investigation level. At first glance, this may seem suboptimal, since the quantity to be controlled is the amount of radioactive substance, i.e. the activity (usually measured in Bq or in the older unit Ci). However, a source of specific activity may be either found or missed with the same detection equipment, depending on factors such as distance, shielding and geometry. Though it is still desirable to find all sources exceeding a specific activity, for the purposes of testing and comparing equipment, and especially for setting reproducible investigation levels, the radiation intensity (i.e. dose rate) at a specific location is a much more reliable basis and has therefore been chosen as the criterion for the investigation level in the IAEA TECDOCs [5, 13, 16].

This was an important lesson in the ITRAP project. Other testing programmes trying to characterize monitoring equipment by their capability to detect a certain amount of activity usually find themselves hard put to standardize their test environment. For example, monitoring for radioactivity contained in steel scrap might be performed by loading a typical truck with a shipment of steel fragments of average density and burying a source with typical shielding arrangements at a certain depth. Detection capability will depend not only on the amount of scrap metal between the source and the detector. The 'typical' assumptions may render this test unsuitable for a different installation that has other 'typical' parameters. There could be other confounding factors that influence the test; for example, one specific truck might cause problems due to electromagnetic interference. As relevant as the question of the absolute quantity of activity contained in scrap is to the scrap recycling industry, the actual signal processed by the monitor is a radiation intensity seen by the detecting element, irrespective of the activity causing it. Again, this becomes a challenge to the standards communities to come up with reasonable specifications and corresponding test procedures, as indicated earlier in this section.

As of now, an International Organization for Standardization (ISO) project (TC85/SC2/WG20) is under way entitled Monitoring for Inadvertent Movement and Illicit Trafficking of Radioactive Material, whereas the IEC is working on Hand-held Instruments for the Detection and Identification of Radioactive Isotopes (SC45B/WG B15). The most recent IAEA TECDOCs have already been mentioned [5, 13, 16].

4.2.2. Operating environment

As stated above, the specific amount of radioactivity (i.e. activity) is the quantity to be controlled under regulatory practices. However, detection based on source quantity is feasible only in certain situations where geometry, shielding and type of radiosiotope are exactly known (or may be controlled). Such is the case, for example, for pedestrian monitors at access control points in nuclear facilities. These monitors are characterized by the amount of SNM (Pu or HEU) they may identify under worst case conditions. Under less defined circumstances, the detection system would have either to identify additional information required (e.g. the radioisotope concerned) or to work on assumptions that may yield misleading results. The major challenge here lies in designing the appropriate monitoring set-up to control as many parameters as possible. For large portals, monitoring of passage speed is almost commonplace.

The shielding effect through the load itself (background suppression) is processed by a few instruments. Active interrogation systems can assess shielding effects within a consignment. The challenges here are both technical in nature and design related, and a cost–benefit analysis will be required in all cases.

4.2.3. Training and support needs

As indicated in Section 3.5, the importance of training and support was one of the major lessons learned during the ITRAP project. The resulting challenge can be stated simply: training and support must be designed to fit the needs of the user (mostly front-line officers) and for the specific equipment foreseen. Detection equipment has been known to be simply switched off, when training had not prepared the users for the occurrence of false alarms. In a manner similar to the defence in depth concept, which makes use of a multilayered structure, appropriate support will consider a multilayered response mechanism. The method of choice during ITRAP testing was a telephone hot line for expert support of the front-line officers. The main challenge lies in a comprehensive approach which will allow the complete system (instruments, procedures, people, response strategy) to operate smoothly.

5. CONCLUSION

The variety of instruments and detection techniques available to aid in combating illicit trafficking and inadvertent movement are numerous. General considerations and experience may be drawn from the pilot study in order to assist with specific implementations in this area. Important factors are the requirements adopted regarding detection probability and false alarm rate, but — equally important — the preparation of the officers responding to alarm scenarios in terms of training, definition of response procedures and support must be carefully observed. Present and future challenges can be found in technological areas (such as the human–instrument interface or radionuclide identifiers) but also in other areas of administrative, standardization, or training and support issues.

Current development efforts are focused on the arena of multipurpose instruments, allowing localization and identification of radionuclides in the field. Corresponding recommendations have already been published in IAEA TECDOCs on prevention, detection and response [5, 13, 16]. Both the ISO and the IEC are carrying out international standards projects to lay down minimum operating specifications for instrumentation employed in counteracting illicit trafficking or inadvertent movement of radioactive sources.

ACKNOWLEDGEMENTS

With regard to the ITRAP pilot study, the Austrian Research Center wishes to acknowledge the support received from the Austrian Ministries for Science, Transport, Interior, Foreign Affairs and Finance under the co-ordination of the Federal Chancellery. The support and co-operation of the IAEA have made this project possible; however, the dedication of the manufacturers has made the project a success. To all of them we are greatly indebted.

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PANEL DISCUSSION 1

INTERDICTING ILLICIT TRAFFICKING

Chairperson: **T. Zhantikin** (Kazakhstan)

Members: **I. Avin** (Belarus)
L. Salgó (Hungary)
C. Schmitzer (Austria)

A.J.A. Al KHATIBEH (Qatar): Radiological dispersal devices are not the only means of spreading radioactive material. One can inject it into water supply systems and achieve an equally strong psychological effect, with less risk of being caught.

C. SCHMITZER (Austria): I tend to agree with you. Prior detection through monitoring would be more difficult. It would be necessary to rely more on intelligence.

P. DAURES (European Commission): Given the high costs of border monitoring, perhaps neighbouring countries could install common portal monitors at their common borders, any alarms being noted simultaneously on both sides of the border. That would reduce the costs.

I. AVIN (Belarus): I think that joint border monitoring could be very effective. The possibilities should be discussed at the bilateral and multilateral level by governments, with the participation of law enforcement agencies and interested international organizations.

C. SCHMITZER (Austria): I believe that joint border monitoring is an excellent idea. It would help to bring down the costs to the individual countries and also help with the correct interpretation of alarms, many of which have innocent causes, for example naturally occurring radioactive substances or radioisotopes which have been used for medical diagnostic purposes.

I. OTHMAN (Syrian Arab Republic): I think joint border monitoring would benefit my country. We have nine border crossing points where we introduced radiation monitoring after the Chernobyl accident, installing — with financial support from the Government — facilities for monitoring foodstuffs entering the country either for internal consumption or en route to the Gulf region; and then we started to monitor as a way of preventing illicit trafficking in radioactive materials. Each year, the nine border crossing points are passed well over 150 000 times by trucks and well over 200 000 samples are taken for radioactive contamination checks.

The monitoring at our borders with Lebanon, Jordan, Turkey and Iraq is expensive for us and for those countries.

J.T. ZERQUERA (Cuba): The detection equipment necessary for interdicting illicit trafficking in radioactive sources is expensive, especially for developing countries, most of which also lack the technical infrastructure needed for repair and maintenance. What can be done about this problem?

C. SCHMITZER (Austria): It is a serious problem, but I hope that organizations like the IAEA will help to solve it.

A. NILSSON (IAEA): Given the importance of border monitoring for efforts to prevent terrorist and other malevolent acts involving radioactive sources, I would be interested in hearing whether the panellists consider that all border crossing points, in both developed and developing countries, should be equipped with radiation monitoring systems.

L. SALGÓ (Hungary): I do not know what would be the most efficient use of resources.

In Hungary, our system — with fixed monitors at 36 border crossing points, and customs officers equipped with 68 handheld detection devices and using over a hundred personal detection devices — works well. Even so, we are planning to acquire further monitoring equipment in the near future.

C. SCHMITZER (Austria): Like Mr. Salgó, I do not know what would be the most efficient use of resources. At all events, border monitoring is, in my view, necessary but not sufficient; there also needs to be, as a kind of backstop, monitoring at internal checkpoints, as in the case of some European Union Member States that are within the Schengen border.

R. ARLT (IAEA): At the IAEA, we are developing equipment for border monitoring, and we have learned informally that similar development efforts are under way in several IAEA Member States. Also, the standardization of border monitoring equipment is being pursued within organizations such as the ISO and the IEC, but the process of arriving at a consensus on technical specifications is very time consuming and we feel that we cannot wait. We would therefore like to see the establishment of a mechanism that would bring all interested parties together regularly for information exchange. An initial step might be a technical symposium on topics relating to the development and standardization of border monitoring equipment, to take place in 2004. I would be interested in hearing the views of panellists regarding that idea.

C. SCHMITZER (Austria): I am not sure whether such a technical symposium would be the best initial step, but I would welcome the establishment of a mechanism of the kind which Mr. Arlt seems to have in mind. I hope that such a mechanism would, among other things, help to increase decision makers' awareness of the need for sophisticated and standardized border monitoring equipment.

The IAEA is already playing an important role in bringing people together, encouraging co-operation and promoting research and development, and I am sure that it could help in bringing about a consensus on technical specifications.

I. AVIN (Belarus): In line with what Mr. Schmitzer just said, I believe that the IAEA could play a very useful co-ordinating role. For many countries, however, the main problem is a lack of financial resources for the purchase of sophisticated border monitoring equipment. But perhaps that problem could be solved within the framework of the IAEA.

D. LEXA (Austria): In my view, the installation of portal monitors at official border crossing points may create a false sense of security. At many borders, for example the border between Mexico and the USA, large numbers of people cross illegally, at places other than official border crossing points. The smuggling of radioactive sources is most likely to occur at such places.

I. AVIN (Belarus): The problem of the illegal crossing of borders at places other than official crossing points has to be tackled by other types of specialized personnel using other methods and technical means.

Preventing the illegal crossing of borders at such places is an important aspect of the fight against terrorism. In Belarus and elsewhere, it can be achieved through the pooling of resources of law enforcement agencies and the relevant ministries and scientific institutions.

S. KONDRATOV (Ukraine): Could Mr. Schmitzer speak briefly about the concept of design basis threat referred to in his presentation.

C. SCHMITZER (Austria): The result of a threat assessment might be a recommendation to monitor not only for orphan sources but also for nuclear materials. That would call for both a γ measuring and a neutron measuring channel in the detection instrument. The decision would depend very much on a country's national policy based on the most likely threat scenario.

SUMMARY OF PANEL DISCUSSION 1

Mr. Salgó pointed to comprehensive legal and regulatory systems, an extension of the physical protection regime for nuclear materials to other radioactive materials, increased information exchange and co-operation with international organizations, and an international tagging system as measures to improve the control and protection of sources. He noted that the synergies between these measures were a strong argument for a comprehensive and co-operative international response to combating illicit trafficking. Mr. Salgó reviewed the experience of Hungary in these areas, noting the importance of a comprehensive approach and of effective intelligence gathering. In the area of security, Mr. Salgó stated that Hungary is considering extending the approach used for the physical protection of nuclear materials to the most dangerous radioactive sources as defined in the IAEA Categorization of Sources.

Mr. Avin reviewed the experiences and problems of Belarus in combating illicit trafficking. These are largely the result of its geographical position and role as the outer border of the CIS customs union. Well over half of the cases of trafficking detected since 1996 involved material in transit. Mr. Avin stated that 8 of the 32 road and 1 of 19 railway border crossing points were equipped with fixed monitoring equipment. For cost reasons, the remainder relied upon handheld detectors. Of the fixed installations, two had been automated with assistance from the IAEA. Mr. Avin highlighted improved co-ordination of national efforts, improved long term support and maintenance for tactical equipment, expanded training and further development of international technical co-operation as the priority areas for the future.

Mr. Schmitzer reviewed the framework, development and results of the ITRAP project. The objectives had been to assess commercially available detection and monitoring systems and to derive internationally agreed minimum specifications. Mr. Schmitzer stated that the key issues in developing detection equipment were determining the threat, specifying the material to be detected and identifying the operating environment. Effective application was determined by good training and response strategies.

During the discussion period, speakers from the floor emphasized the need for enhanced national and international co-operation in the areas of information exchange, training and communications. In particular, there was support for pooling resources by sharing the costs of monitoring equipment between States with common borders, for the continued development of the IAEA's Illicit Trafficking Database and for co-ordinated development of equipment. Speakers also emphasized the importance of training, without which the effectiveness of equipment was much reduced, and the need to expand the availability of training.

On the issue of equipment, several speakers during the discussion period pointed to the need for improved use and maintainability of monitoring and detection equipment through the provision of extended technical and training support. Others referred to the importance of cost effectiveness, user friendliness and harmonization of standards and technologies.

ROLES AND RESPONSIBILITIES

(Panel Discussion 2)

Chairpersons

M. Aramrattana
Thailand

W. Tonhauser
IAEA

ROLES AND RESPONSIBILITIES: ICRP RECOMMENDATIONS

R.H. CLARKE
Chairman, International Commission on Radiological Protection
E-mail: roger.clarke@nrpb.org.uk

Abstract

The paper discusses the role of the International Commission on Radiological Protection with respect to the safety of radioactive sources, the 2005 system of protection, factors in the choice of new constraints and the optimization of protection.

1. INTRODUCTION

The role of the International Commission on Radiological Protection (ICRP) with regard to the safety of radioactive sources is set out in its current 1990 recommendations. These are intended to provide a basis from which to derive necessary regulatory requirements and to give guidance to operating managements. The widespread adoption of the recommendations has the advantage of giving a consistency to the aims and standards across a wide range of countries.

The form of regulatory agencies, their requirements and their methods of operating differ widely around the world. ICRP does not prescribe the nature of the regulatory requirements but assumes countries using radiation sources have established the necessary infrastructure for responsibility, authority and accountability. Its recommendations can then inform the regulators about necessary requirements and provide guidance to operating managements.

The regulatory agency or the government is responsible for the justification of the practice that introduces sources that lead to actual or potential exposures, not ICRP. One feature of the regulation of practices is the use of source related constraints to be applied to the optimization of protection. ICRP has recommended constraints for the normal operation of sources, and for protection against potential exposures (Publication 76). In the event of an accident, ICRP has also given guidance about constraints for optimizing intervention actions (Publication 63) and, in a recent report (Publication 82), the ICRP recommendations are applied to the control of prolonged exposures from long term contamination.

ICRP is currently preparing its new 2005 recommendations, which are intended to simplify the system of protection and to provide a single set of comprehensive source related constraints to be applied to the optimization of protection in a wide range of situations. These should guide international agencies in the setting of standards, which provide the basic level of health protection. The process of optimization, that is reducing exposures as far below the standards as is practicable and reasonable, is to be clearly specified as the responsibility of operating managements and regulators, not of international or regional agencies.

2. 2005 SYSTEM OF PROTECTION

The system of protection being developed by ICRP is based upon the following principles, which are to be seen as a natural evolution of, and as a further clarification of, the principles set out in the 1990 recommendations. Once the source is justified by the appropriate authorities, the radiological principles may be expressed as:

For each source, basic standards of protection are applied for the most exposed individuals, which also protect society.

CONSTRAINTS

If the individual is sufficiently protected from a source, then society is also protected from that source.

However, there is a further duty to reduce doses, so as to achieve a higher level of protection when feasible and practicable. This leads to authorized levels.

OPTIMIZATION

This system of protecting individuals and groups is intended to provide a more coherent basis for protection than the previous one. A necessary basic standard of protection from each relevant source is achieved for individuals by setting constraints that are values of quantities, usually dose, but which may be activity concentrations. Constraints are usually annual values, but may be a single value depending on the circumstances.

These constraints or basic levels of protection can be recommended by ICRP and accepted internationally. The responsibility for optimization then rests with the operators and the appropriate national authority. The operator is responsible for day to day optimization and also for providing input to the optimization that will establish authorized levels for the operation of licensed practices. These levels will, of necessity, be site and facility dependent and beyond the scope of ICRP.

3. FACTORS IN THE CHOICE OF NEW CONSTRAINTS

The present system, which is unduly complex and has used at least six different methods to determine the nearly 30 numerical values for constraints, has set maximum values that are in general about ten times the global average natural background. It is at around this level that doses are usually deemed to require some action, whether they are for practices or intervention, workers or the public.

ICRP now considers that the starting point for selecting the levels at which any revised constraints are set is the concern that can reasonably be felt about the annual dose from natural sources. The existence of natural background radiation provides no justification for additional exposures, but it can be a benchmark for judgement about their relative importance. The worldwide average annual effective dose from all natural sources, including radon, as reported by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) is 2.4 mSv.

A general scheme for the degree of concern and the level of exposure, as a fraction or multiple of the average annual natural background, is shown in Table I. The fact that the effective dose from natural background varies by at least a factor of 10 around the world, and even more if the highest radon doses are included, supports the view that concern should begin to be raised at the higher end of the natural range.

At even higher levels of individual effective dose, i.e. more than 100 mSv in a year, the risk from a source cannot be justified, except in extraordinary circumstances such as life saving measures in accidents, or in crewed space flights. Individual doses of the order of 500 mSv, if acute, can cause early deterministic effects, or if either acute or delivered over decades, can cause significant probability of increased cancer risk. This then becomes restriction on dose related to the individual, and the appropriate authorities must ensure that the individual is not likely to receive a significant additional dose from other controllable sources.

At the other extreme, additional effective doses far below the natural background effective annual dose should not be of concern to the individual. Provided that the additional sources come from practices that have not been judged to be frivolous, these doses should also be of no concern to society. If the effective dose to the most exposed is, or will be, less than about 0.01 mSv in a

TABLE I. LEVEL OF CONCERN AND INDIVIDUAL EFFECTIVE DOSE

High	Greater than a few hundred millisieverts
Raised	Greater than a few tens of millisieverts
Low	Typically 1–10 mSv
Very low	Increments < 1 mSv
None	<0.01 mSv

Note: Global average natural background is 2.4 mSv.

year, then the consequent risk is negligible and protection may be assumed to be optimized, thus requiring no further regulatory concern.

In the intermediate region, doses between a fraction of a millisievert and a few tens of millisieverts, whether they are received either singly or repeatedly, are legitimate matters for concern, calling for action by regulatory bodies.

The challenge is whether fewer numbers could replace the 20–30 numerical values for constraints currently recommended, and further, whether they could also be more coherently explained in terms of multiples and fractions of natural background.

4. OPTIMIZATION OF PROTECTION

ICRP wishes to retain the phrase 'optimization of protection' and applies it both to single individuals and to groups. However, it is applied only after the restrictions are met on individual dose defined by the relevant constraint. It is now used as a short description of the process of obtaining the best level of protection from a single source, taking account of all the prevailing circumstances.

ICRP has previously stated that the previous procedure had become too closely linked to formal cost–benefit analysis. The product of the mean dose and the number of individuals in a group, the collective dose, is a legitimate arithmetic quantity, but is of limited utility since it aggregates information excessively. For making decisions, the necessary information should be presented in the form of a matrix, specifying the numbers of individuals exposed to a given level of dose and when the dose is received. This matrix should be seen as a 'decision aiding' technique that allows different weightings of their importance to be assigned to individual elements of the matrix. ICRP intends that this will avoid the misinterpretation of collective dose that has led to seriously misleading predictions of deaths.

The concept of collective dose was also previously used as a means of restricting the uncontrolled buildup of exposure to long lived radionuclides in the environment at a time when it was envisaged that there would be a global expansion in the number of nuclear power reactors and associated reprocessing plants. Restriction of the collective dose per unit of practice can set a maximum future global per caput annual effective dose from all sources under control. If, at some point in the future, a major expansion of nuclear power were to occur, then some reintroduction of a procedure may have to be considered to restrict a global buildup of per caput dose.

The process of optimization may now be expressed in a more qualitative manner. On a day to day basis, the operator is responsible for ensuring the optimum level of protection, and this can be achieved by all those involved — workers and professionals — always challenging themselves as to whether protection can be improved. Optimization is a frame of mind, always questioning whether the best has been done in the prevailing circumstances. For the more formal authorizations, which are decided by the regulator in conjunction with the operator, they may in future best be carried out by involving all the bodies most directly concerned, including representatives of those exposed, in determining, or in negotiating, the best level of protection in the circumstances. It is to be decided how ICRP's recommendations will deal with this degree of societal process. However, the result of this process will lead to the authorized levels applied by the regulator to the source under review.

5. CONCLUSION

ICRP will continue to aim at providing advice on the system of radiological protection, which supports international agencies and national regulators in establishing the necessary infrastructures that guarantee security of sources.

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ROLES AND RESPONSIBILITIES OF GOVERNMENT AUTHORITIES IN THE REGULATION OF RADIOACTIVE SOURCES

Yuming XU
China Atomic Energy Authority,
Beijing, China

Abstract

The paper examines the roles and responsibilities of government authorities in the regulation of radioactive sources, both in China and the rest of the world, and the role of the IAEA in promoting this regulation. The paper also discusses the importance of international co-operation, especially in the regulation of radioactive sources. China has established an effective regulatory system, which is described along with the next steps to be taken in strengthening this system.

1. CHINESE GOVERNMENT AND THE PREVENTION OF NUCLEAR TERRORISM

The Chinese Government combats terrorism, including nuclear terrorism, and believes that each government has the duty to protect against nuclear terrorism and that the international community should strengthen co-operation in its activities against it. The potential for nuclear terrorism, such as attacks on nuclear installations or the threat or use of a 'dirty bomb' containing radioactive material, should be assessed, and necessary preventive measures should be taken.

The Chinese Government supports the IAEA's contribution to protection against nuclear terrorism, which is based upon the principles in the IAEA's Statute. However, the Chinese Government believes that, in addition to the international community, including the IAEA, implementing preventive measures against nuclear terrorism, co-operation in the peaceful uses of nuclear energy should be greatly increased. Technical co-operation with and support for developing countries should be expanded and help should be given to develop their economies, end poverty, improve medical facilities and enable sustainable development in order to protect against and eradicate nuclear terrorism.

2. ROLES AND RESPONSIBILITIES OF GOVERNMENT AUTHORITIES

Each government has direct responsibility for and plays an important role in the regulation of radioactive sources. Governments should pass relevant laws and regulations for the effective control of the various aspects of the production, use and movement of radioactive sources. Various government departments and services, such as departments of industry, health, public security, environmental protection and emergency management, and the customs service, have their role in the regulation of radioactive sources. Many effective measures have been taken worldwide to deal with the regulation of radioactive sources; however, in recent years, some severe accidents associated with radioactive sources have occurred, which shows that there are some weak points in the administrative process and that all countries need to make improvements by incorporating international experience and good practice.

The IAEA plays a unique role in promoting the better management of radioactive sources, and, as part of its programme, aims to promote the regulation of radioactive sources in Member States by publishing technical and instructional documents. Key documents published by the IAEA include:

(a) Radiation Protection and the Safety of Radiation Sources [1], which presents the objectives and principles of safety in the use of radioactive sources.
(b) International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources [2].
(c) Code of Conduct on the Safety and Security of Radioactive Sources. As an aid in the establishment and co-ordination of policies, rules and regulations for the safety and security of radioactive sources, the Code of Conduct helps Member State governments strengthen the supervision and control of radioactive sources and radioactive material, and gives appropriate consideration to the measures required to ensure its extensive application.

The major recommendations proposed by the IAEA in the documents mentioned above include:

(1) The establishment of a national regulatory authority for the safe management of radioactive sources. To ensure its independence, the regulatory authority should be independent of the administrative departments responsible for radioactive sources and the management of radioactive material. Governments should entrust the appropriate rights

to the regulatory authority and provide adequate support and resources. Periodic assessments should be carried out in order to enable the implementation of the regulatory authority's policies.

(2) The establishment by the regulatory authority of a unified registration system for radioactive sources. The regulatory authority should possess basic information and data on the radioactive source inventory for which it is responsible. Licensees should carry out their responsibilities, ensure the continuous control of radioactive sources and guarantee effective actions in the event of an emergency.

(3) The education and training of personnel by Member State governments, which is regarded as the most important means of achieving the safety of radioactive sources.

(4) Improving feedback from incidents and accidents involving radioactive sources, in order to prevent the occurrence of similar incidents or accidents.

(5) Improving the control of spent radioactive sources. It should be clearly stipulated in the procurement contract that spent sources should be returned to the supplier. It is also recommended that regulatory authorities make measurements at recovery or storage sites for scrap iron and steel. In the event that a lost radioactive source is found at such a site, the handling and recovery of the source should be carefully managed.

(6) Enhancing the public's understanding of the hazards of radioactive sources.

(7) Improving co-operation between the regulatory authority and law enforcement bodies of the State, and improving co-operation worldwide.

The recommendations proposed and the actions taken by the IAEA are positive in promoting Member State governments' efforts to improve the security of radioactive sources.

In addition, the International Criminal Police Organization (ICPO-Interpol) and the World Customs Organization are playing an important role in co-ordinating the prevention of and the fight against cross-border crimes.

3. REGULATION OF RADIOACTIVE SOURCES IN CHINA AND THE NEXT STEPS

The Chinese Government attaches great importance to the security of radioactive sources, and, since the 1980s, has successively issued a series of administrative rules and provisions, such as the Regulations of Radiation Protection against Radioactive Isotopes and Radiation Installations (Order No. 44 of the State Council), in order to control strictly the production, use and distribution of radioactive sources. An effective regulatory system has been set up and various departments of the Chinese Government, including the departments of health, environmental protection, public security, customs and general administration, and the China Atomic Energy Authority, carry out management in accordance with their specific areas of responsibility, including licensing, protection control, accident control, protective supervision of radioactive sources and emergency response. About 50 000 radioactive sources on the Chinese mainland are under effective control, and most of the sources reported as lost have been recovered.

In 2002, related government departments jointly carried out a six month project in which, nationwide, 1524 unused or spent radioactive sources were recovered and properly managed. Furthermore, the Chinese Government allocated a special fund for the collection and storage of more than 10 000 used or spent radioactive sources, and the regulations were strengthened. Through these efforts, those organizations using radioactive sources have generally improved and strengthened their security measures, and there have been significantly fewer incidents of radioactive sources being lost.

The Chinese Government will make efforts to enforce the secure management of radioactive sources by learning from the experience of other States. The Chinese Government feels that the priorities for enforcing the control of radioactive sources are:

(a) Developing and enacting relevant laws and regulations;
(b) Building a scientific regulation system that covers the lifetime of a source;
(c) Focusing on spent sources and setting up a better market operation mechanism;
(d) Emphasizing the training of personnel and actively participating in relevant international co-operation.

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ROLES AND RESPONSIBILITIES OF MANUFACTURERS, DISTRIBUTORS AND USERS

T. VIGLASKY
Directorate of Nuclear Substance Regulation,
Canadian Nuclear Safety Commission,
Ottawa, Canada
E-mail: viglaskyt@cnsc-ccsn.gc.ca

Abstract

The heightened concern over the control and security of radioactive sources has led to an assessment of the roles and responsibilities of manufacturers, distributors and users of sources. However, any role for the industry in these areas must be integrated with the roles, responsibilities and requirements of the regulators. Any initiatives and strategies to enhance the control and security of radioactive sources should be based on the risk posed by the use of the sources. The IAEA has developed a risk based categorization of sealed sources which can be used to guide Member States. A life cycle approach to source management is critical in maintaining both the short and long term control over sources. Issues such as the design of sources and devices to make them less attractive for malevolent use; tracking the use, transfer and disposal of sources; and putting international agreements in place need to be considered.

The purpose of this paper is to present a few introductory considerations regarding the roles and responsibilities of manufacturers, distributors and users in terms of strengthening the control and security of their radioactive sources. Any enhanced role for the industry in these areas must complement and be integrated with the roles, responsibilities and requirements of the regulators. The co-ordinated efforts of these parties will be required for effective and efficient control.

A life cycle approach to source management is a cornerstone in strengthening the long term control and security of radioactive sources. Each stage of the life cycle of radioactive sources — fabrication, distribution, transfer, use and disposal — has its own unique needs for control and security. In determining what these needs are, it is necessary to develop a risk based approach to prioritize the allocation of resources to ensure that any source management initiatives and strategies are effective and are carried out efficiently. Attention must be focused on the high risk sources and applications.

The IAEA has developed a risk based categorization of sealed sources. Member States' initiatives should be in harmony with the categorization work that has already been done by the IAEA.

Nuclear regulators have various mandates when it comes to regulating radioactive sources, and these differences should not be ignored when addressing the issues of life cycle control of sources. In Canada, the nuclear regulator, the Canadian Nuclear Safety Commission, has as part of its mandate the requirement to regulate the production, possession, use and transport of nuclear substances to protect health, safety and security. It carries out these functions via a comprehensive regulatory licensing regime. Licensees are required to conduct their activities within their authorizations and with due diligence. Most national nuclear regulators have similar mandates and regulatory licensing programmes.

The challenge that will need to be resolved is how to achieve the objectives of these well developed regulatory programmes and to adequately address the need to increase the control and security of radioactive sources without unduly restricting the medical, industrial, academic or research benefits received from their use.

Each phase of the life cycle of a radioactive source has unique control and security concerns which need to be addressed. The first phase is the manufacture of the radioactive sources and the design of the devices in which they are installed. It is at this stage that the first steps can be taken towards dealing with concerns over the ease of theft of the source, and the degree of dispersability of the radioactive material if the sealed source is breached. Initiatives should be undertaken to reduce the production of easily dispersable radioactive material used in sources, to investigate how devices can be designed so as possibly to make the radioactive source a more secure integral part of the device, and to make sources less attractive for malevolent purposes. Since radioactive source production is centralized in a relatively few countries, which supply thousands of users throughout the world, it may be possible to achieve relatively large benefits by focusing efforts on this small industry group.

The second phase of the life cycle of a radioactive source is when distributors or manufacturers transfer or sell sources to users. Generally regulators require that anyone wishing to use a radioactive source be authorized to possess and use the source for a specific reason. It is the responsibility of regulators to verify that the individuals are legitimate entities with valid reasons for wanting to possess the source, that they are qualified to carry out the authorized activities, and that they will make adequate provisions to ensure health, safety and security. During this stage, the manufacturer's or distributor's responsibility is to verify that they only transfer the radioactive source to a holder of a valid authorization. In reality, this can only be done within their own national borders. An exporter cannot be expected to have the resources and expertise to assess the creditials of a buyer in a foreign country.

In some situations, the manufacturer or distributor will also install sources into devices, and provide management oversight training regarding safety culture, worker training, and security measures and procedures.

In order to control and verify security during the transfer and use of sources, regulators must ensure that adequate source tracking is being carried out. Some methods by which this can be accomplished could include requiring the manufacturers and distributors to:

(1) Manufacture sources with unique identifiers,
(2) Obtain authorization information for possession and use from the users,
(3) Provide transaction records to the regulatory body,
(4) Maintain a record of disposition of returned sources.

Additional requirements may need to be imposed on users to ensure that they apply appropriate control and security measures during the use, storage and transfer of radioactive sources.

Consideration should also be given to requiring manufacturers or suppliers to inform the regulator of unusual ordering behaviours, such as requests for sources with higher activities, requests for more sources than normal and changes in the frequency of orders.

These steps would improve the overall control and security of sources within national boundaries. However, as mentioned previously, the handful of countries which manufacture the world's supply of radioactive sources are not able to exert the same level of regulatory control over buyers in other countries. In most cases, there is very little regulatory oversight in controlling the export of sources. Currently exporters are only able to carry out a limited verification that buyers are authorized to possess the sources being sought.

Clearly the verification of the legitimacy of end users and their possession of proper authorizations, and that adequate provisions for the safety and security of sources are in place, can only be carried out by regulatory bodies.

The final phase of the life cycle of a radioactive source is its disposal or recycling when it is no longer wanted. The cost of properly disposing of an unwanted source is a financial burden users would rather not have. Manufacturers and countries should be urged to facilitate the return of unwanted sources to entities that can provide the necessary controls. It will always be better to do this than to leave the sources in the possession of individuals with no desire or resources to implement adequate measures of control or security.

One issue that is an obstacle for manufacturers in readily accepting the return of unwanted sources is the uncertainty of future disposal costs.

Additionally, the evolution of transport regulations and their international implementation sometimes makes return of old sources and equipment difficult or impossible.

Acceptance of the principles for controlling the export of radioactive sources, as put forth in the Code of Conduct on the Safety and Security of Radioactive Sources, and their implementation through international agreements would enhance the overall control and security in both the short and the long term.

In summary, efforts to enhance the control and security of radioactive sources cannot be carried out in isolation by the regulatory authorities. Collaboration with manufacturers and suppliers of sources is needed when developing and implementing an overall regulatory regime.

WASTE MANAGEMENT ORGANIZATIONS

E. KETTUNEN
Radiation Practices Regulation,
Radiation and Nuclear Safety Authority (STUK),
Helsinki, Finland
E-mail: eero.kettunen@stuk.fi

Abstract

Radiation sources should be under a regulatory control system during their lifetime. When a source comes to the end of its useful life from the user's point of view, there should be good alternatives for the user to dispose of it. Waste management organizations play an essential role in the safe and secure handling of disused sources and radioactive waste. Disused sources and waste have to be under strict control up to their final disposal. The paper describes examples of the management of disused sources and radioactive waste in various countries.

1. INTRODUCTION

After use, radioactive sources require safe disposal services. A source can be defined as disused when it is no longer required for use, whether or not it has reached the end of its working life. Users have several options for managing a disused source. They can:

- Store it at the user's facilities (temporary storage);
- Return it to the source producer or supplier;
- Transfer it to another user for reuse;
- Send it to a central storage facility, which may be government or privately owned.

At a later phase the source can be sent to long term interim storage before final authorized disposal, if available.

The key issue for safety and security is to keep the radioactive source under proper regulatory control on a cradle to grave basis.

Radioactive sources that are no longer needed must be treated as a potential radiation hazard. To keep the disused source at the user's facility increases the risk of its being lost from regulatory control. For that reason it is important to provide users of radioactive sources with adequate disposal alternatives at a reasonable cost, in either government or privately operated disposal facilities.

This paper describes examples of waste management organizations in some countries and discusses topics relevant to security in the waste management process from end user to final disposal.

2. EXAMPLES OF WASTE MANAGEMENT ORGANIZATIONS AND DISPOSAL ROUTES

2.1. Austria

The regulator holds the records of the sources in the county. There is no distinction in the records as to whether the sources are in use or not in use.

The disposal route of the sources has to be defined in the licence. The sources can be returned to the supplier, or if this is not possible, sources are transferred to the Seibersdorf facility. Seibersdorf is a nuclear research centre and has a contract with the Government to provide a national waste management service.

There is one national storage facility (at Seibersdorf), which is owned and operated by the Government. This facility is responsible for disused sealed sources, and it will not take disused sources from other countries. The type of facility is a secure building.

In storage, α sources are segregated from β and γ sources. All the sources are conditioned, and the conditioned wastes are stored in an engineered above ground storage facility. Sources are stored separately according to their half-lives.

The storage capacity is expected to be sufficient until 2012. There is no final disposal facility in Austria.

Detailed records of the inventory of sources in storage and details of each individual source are held by the Seibersdorf facility. The federal chancellery is provided with details of the conditioned sources on an annual basis [1].

2.2. Belgium

Users of radioactive sources are not required to inform the regulator of their holdings of disused sources. There is a tendency for users to store disused sources at their facilities. Recognized experts are required to check sources regularly, and they encourage users to dispose of sources which are not in use.

Many sources are returned to the manufacturers for disposal. Disposals are reported to the provincial authorities. There are no centralized records of disused sources.

The disposal route of the sources has to be defined in the licence. The licence issued for the use of radioactive material includes a condition that radioactive waste is disposed of through ONDRAF, the organization which is responsible to the Belgian Government for the disposal of radioactive waste. ONDRAF provides the main disposal route for radioactive waste. There is one waste management facility, owned by ONDRAF. The Institut national des radioéléments (IRE) gives its support to ONDRAF by providing temporary storage and the dismantling of sources.

The manufacturer Nordion receives sources from users for disposal. These sources are temporarily held in the production facility pending their transfer in a shielded container to IRE for long term storage [1].

2.3. Denmark

The regulator holds the records of the sources in the country. There is no distinction in the records as to whether the sources are in use or not in use.

The disposal route of the sources has to be defined in the licence. The sources can be returned to the manufacturer, or if this is not possible, they are transferred to Risø National Laboratory.

There is no final disposal route for radioactive waste in Denmark. The issue is not of current interest, because the decision on final disposal is to be made after 20–30 years when DR-3 at the Risø reactor is closed.

There are two main storages at Risø, one for high activity waste underground and one above ground for containers with low surface dose rates. When sources are received at Risø, they are taken into an interim handling storage before being transferred to one of the main storages.

Risø can take almost all types of sources manufactured or used over a long period in Denmark. The only sources which are not accepted are ^{60}Co teletherapy sources manufactured outside Denmark [1].

2.4. Finland

Licensing information about sources is stored in a database maintained by STUK, the Radiation and Nuclear Safety Authority. The database also includes source specific information on sealed sources in the licensee's possession. This information is updated continuously according to licensees' notification and observations made during regular inspections.

The guidance issued by STUK under the authorization given in the Radiation Act specifies that disused sources shall not be stored unnecessarily. There is an annual fee for holding a licence and it depends on the number of sources in the licensee's possession, and therefore there is some financial incentive to dispose of disused sources.

When a new source is authorized for use, the regulator, STUK, requires the applicant to present a plan of measures to be taken when it becomes disused. Essentially there are two options. Either there is an agreement with the supplier for return of the source, or the source will be transferred to the central disposal storage at the expense of the licensee.

There is a central disposal storage in Finland, at Olkiluoto, which is owned by a private nuclear power company. The Olkiluoto site is an underground disposal site in rock. Reactor waste is stored in two silos. The silos are approximately 40 m deep and 20 m in diameter. The company has leased to the Government a side tunnel in the underground disposal site for low and intermediate level waste. This is also a temporary storage for non-nuclear waste. The sources will eventually be moved into the main silos before final closure of the repository in the future.

Disused sources from the field are collected at STUK's laboratory in Helsinki, where they are repacked as necessary and then transferred to the Olkiluoto storage. STUK maintains detailed records of sources stored at Olkiluoto.

In 2002, STUK initiated a campaign to encourage licensees to assess the actual future needs for unused sources at the users' own storages and required the transfer of all sources for which no future was foreseen. As a result, over 200 sources were transferred to central disposal storage or back to the suppliers. The number of sources stored in licensees' premises is now about 600, which is about 10% of the total number of sealed sources in use.

2.5. France

The regulatory system (Conditions particulières d'authorisation, CPA) set rules concerning the disposal route as follows: (1) End users have to remove any source from service ten years after its purchase. (2) The company supplying the source to the end user must include disposal in the purchase price. (3) All other companies in the supply chain have to agree contractually to take back the source after ten years. This means that sources supplied from outside France must be exported from France at the end of their working life.

Sources are returned to the supplier by the end user at the end of their working life. The supplier is responsible for arranging disposal according to CPA rules. The supplier has several disposal options available. They can return the source to the distributor or manufacturer; they can send it to the Commissariat à l'énergie atomique (CEA), which provides long term storage of used sources; or they can find some commercial alternative outside France. Any source manufactured outside France must be exported from France.

ANDRA is the organization for all radioactive waste produced in France, and it has a surface disposal site for low level waste and short lived waste. It cannot dispose of sealed sources at present.

Long term interim storage for disused sources is provided by the CEA. Sources are received for storage at the Saclay site or for recycling at the Marcoule site for reuse in R&D programmes. Sources at Saclay are held in their transport containers.

An inventory of the disposed sources is held by the CEA.

Most of the suppliers of sources belong to an association named Ressources. Each member pays an annual fee based on the number of sources they have delivered to the field. This provides funds for the disposal of sources supplied by any member who becomes bankrupt [1].

2.6. Germany

The disposal route of the disused sources is not defined in the user's licence. There are several options for the user to dispose of the sources. The sources can be transferred to the local interim storage or to a company offering a commercial disposal or recycling service. Each state in Germany is required to ensure that an interim storage facility is available to the users of sources within that state. There are 14 storage facilities (Landessammelstellen) in the 16 states.

Most of the storage facilities provide only a storage service, not any conditioning of waste. Conditioning has to be done prior to delivery to the storage facility. A conditioning service is provided by specialized companies.

The disposal cost is paid by the end user.

There is one final disposal site for disused sealed sources in Germany, in Morsleben. The site is operated on behalf of the Bundesamt für Strahlenschutz (BfS, the regulator) by a contractor, DBE (the German company for the construction and operation of waste repositories). Disused sources are transferred to the BfS facility from the Landessammelstellen and from commercial organizations that have their own short term storages. There are some other sites in preparation that are to be capable of providing final disposal services in Germany.

Commercial disposal companies organize services for the reuse, recycling and long term storage of sources in Germany. There are several companies providing this alternative to end users.

An inventory of the disposed sources is held by each storage site [1].

2.7. Netherlands

The disposal route of the sources can be defined in the licence if necessary. The sources can be returned to the manufacturer, or if this is not possible, they are transferred to a central long term storage.

A long term storage facility is operated by COVRA (Centrale Organisatie voor Radioactief Afval). This is a commercial organization owned mainly by the large waste producers, with a minor share owned by the State.

COVRA is the only organization for radioactive waste management in the Netherlands. It collects all disused sources from any location in the Netherlands and transports them to a central storage. The sources manufactured by OEM manufacturers in the Netherlands are collected from other countries as well.

COVRA has a central facility in Borsele. Waste treatment and conditioning, as well as long term interim storage for low and intermediate level waste, take place in the same facility. The type of storage is a secure building. Solid wastes are cemented into drums for storage.

End users have to pay the cost of the disposal. The cost is based on the volume, and for this reason some customers would like to reduce the volume of the disposed material. There are commercial companies providing this service.

There is no final disposal route in the Netherlands. The policy is to store the waste in a retrievable form [1].

2.8. Spain

The disposal route of the sources has to be defined in the licence. Licensees have to inform the regulator, CSN, of disused sources. This is done during annual inspections, and the regulator applies pressure for the disposal of disused sources.

Users have two options for the disposal route. Sources can be returned to the supplier or be transferred to the waste management organization ENRESA. ENRESA is the only organization for radioactive waste management in Spain. It is a public company and is owned by CIEMAT, which is an agency of the Ministry of Industry and Energy.

ENRESA has its facility at El Cabril, where there is a near surface disposal site. The facility can accept only low and intermediate waste containing short lived radionuclides. Sources which cannot be disposed of at the El Cabril disposal facility are placed in special storage at El Cabril or at CIEMAT premises.

In some cases ENRESA provides a service to remove the sources from the equipment at the user's site. This is only in special cases and for sources with low risk.

An inventory of the disposed sources is held by the regulator, CSN, as well as by the waste management organization [1].

2.9. United States of America

There are three regional facilities in the USA which provide disposal services for low level waste. Most of the states have taken the responsibility for managing their sources through the Agreement States system. These states have formed compacts for operating low level waste disposal facilities. The three facilities are Barnwell, in South Carolina; Hanford, in Washington State; and Envirocare, in Utah.

The waste is classified in four different categories: Class A, Class B, Class C and Greater Than Class C (GTCC), in order of increasing radioactivity levels. This means that the security risk increases from Class A to GTCC. The general rule is that wastes in Class A to Class C are accepted for near surface disposal, while GTCC waste must be disposed of in a geological repository.

Both Barnwell and Hanford facilities can dispose of Class A to Class C waste. Envirocare is currently licensed to dispose of Class A waste. There is no dedicated storage facility for GTCC sources. The users having disused sources in the GTCC category have to wait for the radioactivity level to decay to at least the Class C level.

In 2001 the US Nuclear Regulatory Commission implemented heavier penalties for unauthorized disposal of sources.

The US Department of Energy (DOE) was directed in 1995 to be the federal agency responsible for the disposal of commercial low level waste in the GTCC category. The DOE manages the Off-Site Source Recovery (OSR) Project to provide safe and secure storage at its facilities for GTCC sources. As an example of this project, Los Alamos National Laboratory recovered almost 3000 sealed sources in 2001 and secured them in storage containers. Final disposal for these sources will be developed during the next several years. The OSR Project will be continued, and it is estimated that more than 10 000 sources will be found eligible for collection [2].

2.10. Russian Federation

The disposal of disused sources is managed by RADON, which is the organization responsible for the location and storage of radioactive waste.

RADON has 34 enterprises based regionally throughout the territory of the former Soviet Union. In the Russian Federation, there are 16 enterprises, and the main centre is at Sergiev Posad outside Moscow. RADON is subordinate to the Russian regional governments.

The main federal function for RADON is to service the 2000 enterprises which are generating radioactive waste and disused sources. Disused sources are stored in underground repositories buried at a depth of 6 m. The RADON facilities are capable of managing the disused sources in the Russian Federation.

The challenge in the Russian Federation is in identifying and collecting disused sources throughout the country. The locations of many unauthorized dumps of radioactive sources are unknowns as well [2].

3. CONCLUSIONS

Radiation sources, even individually, should not be allowed to fall out of the regulatory control system. The system should continue to cover them until their final disposal.

Disused sources in the storages at users' facilities are at increased risk of being lost from regulatory control. Therefore it is important to encourage users to dispose of disused sources as soon as possible.

In some countries, licensing information is stored in a database of the regulator and also includes source specific information for all sources in licensees' possession.

The licensee has to present a waste management plan for disused sources before a licence is approved for using radioactive sources. Therefore there should be adequate alternatives for waste management in each country.

In some countries the regulator asks the licensee to provide information about disused sources which are stored at the licensee's premises. This can be arranged during regular inspections.

In some countries the regulator can apply pressure on the user to dispose of disused sources on the user's premises.

In at least one country the annual licence fee is based on the number of individual sources owned by the licensee. This creates some financial pressure to remove disused sources from the user's own storage.

In some countries the regulator has arranged campaigns to recover and collect disused sources in disposal storages, with good success.

Waste management is paid for by the waste producer, the end user. It is important to arrange attractive disposal routes for disused sources activated by the governments. Disposal must be a more economic solution than storage at the user's premises.

Transferring the disused sources from the end user to the waste management services, or between services, is a security issue as well. In some countries transport is arranged by waste management organizations.

Inventories and records of disposed material are held by waste management organizations and are informed to the regulators in some countries.

Training personnel in security matters is an important role in waste management organizations. Competent and knowledgeable people will create an open and caring culture in organizations, which is the basis for successful co-operation.

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PANEL DISCUSSION 2

ROLES AND RESPONSIBILITIES

Chairperson: **M. Aramrattana** (Thailand)

Members: **R.H. Clarke** (ICRP)
P. de Klerk (IAEA)
E.V.S. Kettunen (Finland)
T.P. Viglasky (Canada)
Yuming Xu (China)

L.A. BETANCOURT HERNANDEZ (Cuba): In the light of our experience, I should like to emphasize how important it is that regulatory authorities ensure that the controls over different radioactive sources are appropriate to the source category. Also, regulatory authorities should, when issuing licences for the import and export of sources, ensure that the purchase contract provides for the possible return of the source to the supplier when it is no longer wanted by the user and that unwanted sources are kept in storage for as short a time as possible before being returned.

Moreover, regulatory authorities should promote education of the public with regard to the security of sources and how sources can be recognized.

Lastly, I should like to see the regulatory authorities of different countries exchanging information about shipments of sources, with a view to ensuring that sources are not sent to unlicensed recipients.

A. JÖRLE (Sweden): In Topical Session 2, a reference to radiophobia was made by Mr. Novikov of the Russian Federation, and that prompts me to make the following comment on Mr. Clarke’s presentation.

A group of public affairs officers working in the regulatory field, at a meeting chaired by me, was recently asked about dose levels and release limits, and we agreed that they should be scientifically justified and that one should not insist on technically achievable levels and limits. As we are communicators, we felt that scientifically justified levels and limits were preferable since they are easier to explain.

R.H. CLARKE (ICRP): I welcome that comment. The “as low as technically achievable” release philosophy runs counter to the principles of radiological protection. Our standards are based on a number of scientific criteria, but the process of optimization should be seen as a stakeholder involvement procedure. Regulatory authorities and operators should try to gain public trust by engaging in genuine negotiations aimed at achieving the optimum level of protection.

E. GIL LÓPEZ (Spain): During this conference, there have been two very different kinds of presentation, one focusing on the physical protection of high risk sources and the other on sensitive equipment capable of detecting minute amounts of radioactive material that represent only a very low risk. In my view, the focus of efforts relating to the security of radioactive sources should be on high risk sources.

R.H. CLARKE (ICRP): I believe that it is extremely important to ensure the security of high risk sources. However, after an incident involving a radiological dispersal device (RDD), the people working in the radiological protection field would have to consider a broad spectrum of dose related consequences and communicate with the public regarding low risk contamination.

P.H. ZIMMERMAN (United States of America): I hope that this conference will lead to a change in the way in which we look at radiation protection and RDDs.

The cradle to grave control of radioactive sources can provide some protection against minor terrorist acts involving RDDs. Since 11 September 2001, however, it should be clear that there are terrorists who think in more ambitious terms.

If Al Qaeda or a similar group decides to use RDDs, it will probably purchase the necessary sources, presenting valid licences, or steal them from one or more of the large, vulnerable radioisotope thermoelectric generators (RTGs) that are standing unattended in remote parts of the world, and it will build primitive hot cells capable of being operated by people who are willing to die in the process.

The sources used will be at least in the 10^4 Ci[1] range — probably in the 10^5 Ci range — and will be used in ways far more disruptive, perhaps more deadly, than the detonation of an RDD consisting of a few tens of curies of radioactive material wrapped around a stick of dynamite.

H.D.K. CODÉE (Netherlands): If countries with good infrastructures for radioactive waste management accepted spent sealed sources from other countries, that might help to reduce the risk of terrorist acts involving RDDs, besides helping to prevent accidents like the one that occurred in Goiânia, Brazil, and the inadvertent melting down of sources as occurred in Algeciras, Spain. The acceptance of sources from the developing world would, in my view,

[1] 1 Ci = 37 GBq.

not be a burden for those countries' waste management organizations. What is the opinion of the panellists?

E.V.S. KETTUNEN (Finland): Finland's regulations are based on the principle that we do not accept disused sources from other countries for disposal.

The challenge is an international one calling for an international solution — the provision of assistance designed to ensure that all countries have the infrastructures necessary for taking care of all or most of their disused sources locally.

M. ARAMRATTANA (Thailand): Such assistance is being provided through the IAEA Model Project described by Ms. Cetto in Topical Session 2.

There may in due course, perhaps within the IAEA framework, be some form of international or regional co-operation aimed at the establishment of centralized waste storage facilities for use by groups of countries.

J. TURNBULL (New Zealand): A great deal of equipment includes radioactive sources among its components, the equipment manufacturers purchasing the sources from one of the primary source producers for incorporation into their equipment. Often it is not clear from the documents relating to a piece of such equipment that it contains a radioactive source, so that the regulatory authority of the country where the piece of equipment is being used may not be aware of the existence of the source.

With pieces of equipment incorporating radioactive sources being exported from one country to another, the problem is an international as well as a national one. What can be done about it?

T.P. VIGLASKY (Canada): The problem has been discussed by the working group that is revising the Code of Conduct on the Safety and Security of Radioactive Sources, which advocates the establishment not only of registries of sources but also the establishment — by regulators and source manufacturers and distributors — of systems for keeping track of sources, including ones that become incorporated into equipment.

If every source were provided with a unique identifier, that would help to improve matters.

R. CAMERON (IAEA): At the end of April, we are holding a meeting of regulators and source manufacturers and distributors to consider that problem and related ones. The meeting is being held within the framework of implementation of the IAEA's Revised Action Plan for the Safety and Security of Radiation Sources.

The Code of Conduct on the Safety and Security of Radioactive Sources is being revised within the framework of implementation of the Revised Action Plan, and in that connection I should like to ask Mr. Viglasky whether, in his view, source manufacturers and distributors in countries which adhere to the revised Code of Conduct will be at an undue commercial disadvantage vis-à-vis manufacturers and distributors in countries which do not adhere to it.

T.P. VIGLASKY (Canada): It will be necessary to try to ensure that the revised Code of Conduct is adhered to uniformly throughout the world so that certain source manufacturers and distributors are not at an undue commercial disadvantage. Broad adherence to the revised Code of Conduct should help to create a stable business environment.

C.F. ARIAS (Pan American Health Organization): In my opinion, the possibility of radioactive sources being used deliberately for malevolent purposes — over and above the possibility of radioactive sources causing harm accidentally — may prompt some people to question the justification for beneficial radiation practices involving the use of radioactive sources. Governments and international organizations should make sure that such radiation practices are not jeopardized. The Pan American Health Organization stands ready to support all efforts to that end, especially in those Latin American and Caribbean countries which are not IAEA Member States.

A. HUSEYNOV (Azerbaijan): My country, which has only recently become an IAEA Member State, has an orphan source problem and would like to receive IAEA assistance in dealing with it. Would the IAEA consider providing such assistance?

V. FRIEDRICH (IAEA): The main goal of the Tripartite (Russian Federation–USA–IAEA) Initiative is to recover and secure high risk radioactive sources in the Newly Independent States. As Azerbaijan is a Newly Independent State, it will receive such assistance within the framework of the Tripartite Initiative.

A. ANDRIES (Republic of Moldova): The approximately 6670 radioactive sources in Moldova are under good regulatory control, but we have to think about their temporary storage and repatriation after use. We are grateful for the assistance which we have already received in this connection from the IAEA, the Joint Institute for Nuclear Research at Dubna in the Russian Federation and the US Government.

As Vice-President of Moldova's National Committee for Radio-protection, I welcome the Tripartite Initiative just mentioned by Mr. Friedrich, which I hope will also help my country to solve its problems relating to disused radioactive sources.

In this connection, perhaps consideration could be given to the establishment of regional centres of excellence for education and research directed towards enhancing the security of radioactive sources.

J. MARRIOTT (United Kingdom): How would the currently envisaged radiological weapons treaty help to prevent the use of radiological weapons by terrorists, and, if the treaty covers radioactive sources, how would one decide which sources should be covered?

P. de KLERK (IAEA): A commitment by States Parties to the treaty not to develop radiological weapons would not directly help to prevent the use of radiological weapons by terrorists. This is why the role for the IAEA will remain important. To some extent, the value of a radiological weapons treaty as regards preventing nuclear terrorism would depend on the treaty's provisions — the actions which the States Parties to the treaty would have to take.

As to the question of how one would decide which radioactive sources should be covered by the treaty, the majority of small sources would not be directly relevant. One would have to draw a line between them and the rest.

K. GRYSHCHENKO (Ukraine): The final disposal of radioactive sources is a costly undertaking. Who should pay for it? If the State pays, should it do so from the national budget (which means that the cost is borne by the tax payers), from a fund with revenues from the issuing of licences to source users or from some other special fund?

E.V.S. KETTUNEN (Finland): In my country the principle is that whoever last used the source must pay for its disposal. Hence, when a disused source is received at our central interim storage facility, the last user is charged.

However, other ways of meeting the costs of storing and disposing of disused sources are conceivable.

V. FRIEDRICH (IAEA): One problem about requiring the last user of a source to pay for its disposal is that the last user may not be able to afford to pay and may therefore retain the source, storing it under unsafe and unsecure conditions, or throw it out with the garbage. That problem is particularly likely to arise in developing countries.

One must exercise great care when introducing a fee for the management of disused sources.

SUMMARY OF PANEL DISCUSSION 2

The session was opened by its chairperson, Mr. M. Aramrattana of Thailand. In his opening remarks, he briefly addressed the responsibilities of national government authorities and licensees, as well as the importance of international organizations with respect to the security of radioactive sources. The session comprised short presentations by the panel members followed by a discussion including questions and statements from the floor. Mr. R.H. Clarke, Chairman of the International Commission on Radiological Protection (ICRP), provided an overview of the relevant activities of ICRP and concluded that ICRP would continue to aim at providing advice on the system of radiological protection, which supports international agencies and national regulators in establishing the necessary infrastructures that guarantee the security of sources. Mr. Yuming Xu of the China Atomic Energy Authority addressed the roles and responsibilities of government authorities and briefed the audience on the status of the regulatory framework in China with regard to radioactive sources. Mr. T.P. Viglasky of the Canadian Nuclear Safety Commission emphasized that a life cycle approach to source management is critical in maintaining both the short and long term control over sources. He addressed the roles and responsibilities of manufacturers, distributors and users in this respect. Continuing this approach, Mr. E.V.S. Kettunen of the Radiation and Nuclear Safety Authority of Finland addressed the role of waste management organizations and reviewed waste management approaches and disposal routes in some countries with significant nuclear programmes. Mr. P. de Klerk of the IAEA provided a review of the relevant IAEA activities as an example for intergovernmental bodies.

During the discussion, the cradle to grave approach for radioactive sources to be implemented by both regulators and licensees, the desirability of broad international adherence to the revised Code of Conduct on the Safety and Security of Radioactive Sources, the role of government authorities in communicating with the public, and the costs associated with the final disposal of sources were addressed by the audience and the panellists.

PLANNING THE RESPONSE TO RADIOLOGICAL EMERGENCIES ARISING FROM THE MALEVOLENT USE OF SOURCES

(Panel Discussion 3)

Chairpersons

S.H. Na
Republic of Korea

M. Crick
IAEA

OVERVIEW OF THE RADIOLOGICAL ACCIDENT IN GOIÂNIA

L.A. VINHAS
International Relations Office,
Comissão Nacional de Energia Nuclear,
Rio de Janeiro, Brazil
E-mail: lavinhas@cnen.gov.br

Abstract

In September 1987 a very serious radiological accident occurred in Goiânia, Goiás State, Brazil, when a 50.9 TBq ^{137}Cs source was inadvertently removed from a therapy unit and dismantled by scrap dealers. The spread of contamination was through human contact and distribution of source fragments among friends. Screening for contamination of people established that 249 persons were contaminated, 21 presenting acute radiation syndrome or radiodermatitis and ten in serious condition. Four of these died. Following area radiation surveys, seven highly contaminated sites were identified and isolated. The total area of these sites was 5000 m^2, and they were distributed within an area of 2 km^2, in the central districts of Goiânia. Following the detection of the accident, other mitigation measures took place immediately, such as medical care of patients, and monitoring of the potable water supply, the sewage and rainwater systems, and the money in circulation in Goiânia. The accident had consequences, directly or indirectly, for all inhabitants of the city, and in some aspects for Goiás State as a whole. The consequences were of a social, emotional, psychological and economic nature. A strong discrimination arose against the inhabitants of Goiânia and against the products of all of Goiás State, with deep social and economic impacts. The gross domestic product of Goiás State fell by 15%. During the cleanup operations, seven houses had to be demolished and large amounts of soil had to be removed. The total volume of waste removed from contaminated sites was 3500 m^3; it was placed in 5700 packages. It was necessary to construct a disposal facility to store the waste. The Goiânia accident demonstrated that each accident is unique, particularly in the case of a radioactive source. Nevertheless, lessons learned from the intervention in one accident could be useful on future occasions.

1. INTRODUCTION

In September 1987 a very serious radiological accident occurred in Goiânia, Goiás State, Brazil, when a 50.9 TBq ^{137}Cs source was unwittingly removed from a therapy unit and dismantled by scrap dealers, contaminating several hundred persons and several sites in the city. Goiânia is a city of one million inhabitants located 1000 km from Rio de Janeiro and São Paulo. This accident can be considered unique because of three aspects. It happened in an urban setting of a large town, two weeks elapsed before the accident was detected, and the spread of contamination was through human contact and distribution of source fragments among relatives and friends. This paper describes the accident, the actions to mitigate the consequences, the impact on the people involved and on the society, the cleanup of contaminated areas, the waste disposal and the lessons learned from this experience.

2. HISTORY OF THE ACCIDENT

On 13 September 1987, in Goiânia, two scrap dealers took a ^{137}Cs teletherapy device from an abandoned and partly demolished radiotherapy clinic to their home. There, after several days, they removed the rotating assembly from the shielding head and dismantled the capsule containing 50.9 TBq of ^{137}Cs in the form of highly soluble caesium chloride salt. They showed the pieces to a junkyard owner, who decided to buy the whole lot. In the night the junkyard owner noticed that the material in the source capsule emitted a blue luminescence. Attracted by this phenomenon he resolved to cut the capsule into small pieces and he gave these to his relatives and friends as a gift.

After some days, the persons in close contact with the material were showing gastrointestinal disease symptoms initially diagnosed as dehydration and tropical disease. One of these persons associated the illness with these metallic pieces and transported the contaminated rotating assembly by urban bus to a Public Hygiene Control Unit. At the same time a medical doctor suspected that the symptoms shown by the patients could be associated with radiation exposure (acute radiation syndrome). He asked for the expertise of a physicist, who, using a scintillation detector, observed that some patients were contaminated and verified the presence of radiation in their houses and around the metallic pieces at the Public Hygiene Control Unit. He determined that the contaminated areas must be evacuated. The persons were removed from their houses and were provided shelter in tents at the Olympic Football Stadium. Subsequently, at 3 p.m. on 29 September 1987, the physicist reported the facts by telephone to the National Nuclear Energy Commission (CNEN).

CNEN made the arrangements to send a small team to Goiânia immediately to assess the situation and to take the initial mitigation measures. On the same day, three experts departed from Rio de Janeiro and São Paulo, arriving in Goiânia at around midnight. In the following days, more experts and technicians from CNEN, its institutes, other Brazilian nuclear institutions, civil defence and private companies were sent to Goiânia and joined the intervention team. The number of persons engaged in mitigation actions reached a maximum of 700 during the decontamination phase.

3. MITIGATION OF CONSEQUENCES

Initially the intervention team concentrated its efforts on the following activities:

(a) Clinical evaluation and medical care of the persons presenting acute radiation syndrome or radiodermatitis. A total of 21 patients, ten in serious condition, had to be hospitalized for intensive medical treatment; four of these died and one underwent amputation of the forearm.

(b) Screening for contamination of the evacuated people and persons that had had some contact with them, to perform preliminary external decontamination and to refer cases of persisting contamination to the medical team. In addition to these people, during the first several days following discovery of the accident, thousands of persons went to the screening point to be monitored, moved by fear and panic. In a period of five months following the accident, more than 112 000 persons were monitored; only 249 were contaminated. Among these persons, 125 presented contamination of clothing and shoes only, or very slight external contamination that was easily removed. After the decontamination procedures they were released. The other 124 were referred to the medical team.

(c) Reconstruction of the accident to facilitate the search for contaminated persons and areas.

(d) Implementing radiation protection procedures at the hospital, the Olympic Stadium and the screening point.

(e) Monitoring of the potable water supply system and the sewage and rainwater systems. Several samples were collected from the reservoirs and at different points in the drinking water distribution system. The radiometric results indicated that the potable water of the city was not contaminated by ^{137}Cs. The detection limit was 1.5 Bq/L. Caesium-137 was detected in the samples collected in the sewage and rainwater systems. However, the values found did not present any risk to the population.

(f) Informing the public about the accident through the local newspaper, radio and television.

(g) Shielding of the rotating assembly located at the Public Hygiene Control Unit. The decision was taken to shield this metallic object with maximum urgency in order to reduce the exposure rates (greater than 10 Sv/h near the surface and 4 Sv/h at 1 m), to minimize the number of houses to be evacuated and to avoid the risk of spreading the contamination (the rotating assembly was on a chair in the courtyard). The best solution at the time was to place a concrete sewer pipe around the chair and the assembly using a crane and to fill the pipe with concrete pumped from a distance through a hose.

(h) Identification of the main contaminated foci and isolation of their areas. During the first several days, seven strongly contaminated sites were identified by radiation surveys. The total area of these sites was 5000 m^2, and they were distributed within an area of 2 km^2 in the central districts of the urban area of Goiânia. In the three most highly contaminated sites, it was necessary also to isolate part of the street at the entrance to the site in order to minimize the exposure of people and to avoid contamination of vehicles.

(i) Radiometric surveys to identify additional contaminated sites. The following strategy was adopted to trace new foci: on-site verification of information provided by the contaminated persons, their relatives, friends and the population, and a systematic survey of the city with a scintillator detector set in a vehicle. Points of residual contamination were identified in 46 residences and 50 public places. The great majority of these presented about 0.05 mSv/h and could be easily decontaminated. Only some houses needed to be evacuated temporarily to allow the decontamination operations.

(j) Monitoring of the money in circulation in Goiânia. Considering the time between the occurrence of the accident and its detection, it was prudent to make a systematic check of the money and the local bank offices. More than 10 million bills were monitored; ^{137}Cs contamination was detected on only 68.

4. CONSEQUENCES FOR PEOPLE

Although the number and the extent of areas contaminated by the accident were relatively small, as the accident occurred in the urban area of a large city, it had consequences, directly or indirectly, for all inhabitants of the city, and in some aspects for Goiás State as a whole.

The first impact on the local population was of an emotional character: the feeling of panic, insecurity and stress resulting from the perception that there was not any visible evidence of a large emergency. Although there was no explosion, tremor, fire, smoke, peculiar smell or any other phenomenon that could be associated with an accident of such proportions, people were obliged to leave their houses, several became ill and some died, and a large number of experts arrived in Goiânia to take care of the emergency.

People did not know the mechanisms of contamination for such an accident, but associating it with some contagious disease, they believed that the contamination could be carried by air and affect everyone. This idea was reinforced by comparison with the consequences of the Chernobyl accident. People supposed that in the Goiânia accident the contamination could be spread over large distances through a radioactive cloud, as in the case of Chernobyl. Even educated people also had this idea.

The anxiety of the population was evident, considering the number of persons who reported to the screening point to be monitored without a specific reason: 3000–4000 persons per day during the first two weeks of October 1987.

More than 8000 residents of Goiânia requested and received official certification that they were not contaminated. They used these certificates in an attempt to reduce the discrimination against the inhabitants: hotels in other parts of the country refusing to allow Goiânia residents to register as guests; airline pilots refusing to fly aircraft with Goiânia residents on board; and interstate bus drivers refusing to allow Goiânia residents as passengers on their buses.

The wrong concept of the contamination spread, and unethical economic interests led to discrimination against products from Goiânia and from unaffected regions farther away. Sales of cattle, cereals and other agricultural goods, the main economic products of Goiás State, decreased by more than 20% in the period after the accident.

Following detection of the accident, the number of tourists in Goiânia was severely diminished. Virtually all conventions scheduled for hotels in Goiânia were cancelled or rescheduled elsewhere. In some tourist areas of Goiás State located 200 km from Goiânia, the tourism activities were also reduced.

The reduction in the commercial and tourist activities caused a reduction of around 15% in the gross domestic product (GDP) of Goiás State. It took five years for the GDP to return to the levels before the accident.

5. CLEANUP AND WASTE DISPOSAL

During the month of October 1987, the materials, heavy machinery and containers to be used in the decontamination process were being provided. At the same time it was necessary to construct a temporary storage for the waste generated during this process. Studies for the choice of site and the design of the storage facility began immediately.

The discussion with the Goiás State government on alternative areas to locate the storage took considerable time, which delayed the beginning of the cleanup operation. Finally, an area of about 20 000 m^2 located in Abadia de Goiás, 23 km from the centre of Goiânia, was selected. Nine concrete platforms of 60 m × 18 m × 0.2 m were constructed to receive the waste packages. Aspects related to the drainage, physical protection and access for heavy vehicles were considered. An environmental monitoring programme was established.

The decontamination of the seven highly contaminated sites was performed in the period 10 November–21 December 1987. The cleanup operation took place under unusual conditions owing to the sites' characteristics, their location in an urban area of a large town and the typical tropical weather conditions (intense sunshine with temperatures of up to 38ºC and sometimes heavy rains). It should be emphasized that because of political and social pressures, the decontamination had to be concluded in the minimum time, attaining extremely low radiation levels.

As mentioned in Section 3, seven main foci had been identified. The main characteristics of two sites are described in order to illustrate the unique conditions in which the decontamination work was done.

On the site named Roberto's house (57th Street) there were two houses, occupying about 50% of the 550 m^2 area. The source was broken on this site, transferring large amounts of radioactive material to the ground. By the action of a heavy rainfall, a planar source of 2 m × 2 m was formed, resulting in the most highly contaminated hot spots, with a dose rate of around 1.1 Sv/h at 1 m. Furthermore, generalized contamination was also found in the courtyard and houses, with dose rates of between 0.2 and 5 mSv/h.

The site named Junkyard II had an area of 1250 m^2 (25 m × 50 m). It comprised a house, a wooden shack and a square metallic structure (shed). These occupied around 30% of the yard. Several bundles and piles of paper, plastic wastes, debris and metal junk were spread all over the yard. The initial survey indicated a generalized contamination with dose rates of below 3 mSv/h and 12 hot spots with dose rate levels of up to 2000 mSv/h.

In the highly contaminated sites presenting high dose rate hot spots and generalized contamination with high levels, it was necessary to remove houses and soil layers. Three sites were in this situation, where seven houses had to be demolished and large amounts of soil had to be removed.

Experience showed that the best order in which to carry out the cleanup operation of these sites was:

— Removal, whenever possible, of the hot spots;
— Removal of the loose paper, plastic waste and so forth;
— Removal of the bundles of paper;

— Cutting and removal of the trees;
— Removal of the furniture from the houses;
— Demolition of the houses and wooden shacks, and removal of debris;
— Demolition of metal structures, cutting the girders and removing the pieces;
— Removal of contaminated layers of soil according to soil activity profile measurements;
— Covering the areas with padding soil or concrete.

Four types of radioactive waste package available in Brazil at that time were used: industrial drums of 0.2 m^3 made of 18 gauge carbon steel; ribbed metal boxes with a capacity of 1.7 m^3 and a maximum load of 5 t; one drum concrete overpack (VBA) and shipping containers with a capacity of 32 m^3.

The packages were closed and externally decontaminated before being dispatched from the site in trucks. The vehicles went in convoys accompanied by a police escort. Radiation protection technicians accompanied the vehicles on their route.

The total volume of waste removed from the contaminated sites was 3500 m^3; it was placed in 5700 packages, weighing 6000 t.

Until March 1991, owing to questions of a political nature, no decision had been taken on how to proceed with the waste stored at Abadia. In that month, among the three sites which had been selected by CNEN for the construction of a final disposal facility, the government of Goiás State opted for a site which was contiguous to the temporary storage facility.

According to the IAEA philosophy, all radioactive waste collected in Goiânia falls into the category of low level short lived waste, and the disposal option allows its emplacement at shallow depths, in engineered storage facilities.

Approximately 42.7% of the waste volume has specific activities not greater than 87 Bq/g. Furthermore, most of the recovered activity requiring a decay period than 150 years to reach acceptable concentration levels is distributed over only 16.5% of the total volume. The remaining 40.8% of the waste volume (decay period less than 150 years) needs to be repackaged in concrete containers and in metallic containers to improve conditioning as well as to provide an additional engineered barrier in the near surface repository.

Owing to the above mentioned characteristics of the waste, it was decided to construct two repositories for the Goiânia waste, both at the same site. The construction of the first repository, for waste with specific activities not greater than 87 Bq/g, was concluded in 1995, and construction of the second repository was concluded in 1997.

6. LESSONS LEARNED

The Goiânia accident demonstrated that each accident is unique, particularly in the case of a radioactive source. Several characteristics of an accident will determine the strategy to be followed in the actions to mitigate its consequences and to perform the cleanup process. The Goiânia accident confirmed that the most important characteristics are: the physical and chemical properties of the radioactive source; the type of installation or device of which the source is a part; the geographic area and environment where the accident occurs; and the mechanisms whereby contamination is spread.

Nevertheless, lessons learned from the intervention in one accident could be useful on future occasions. Some lessons learned from the experience of decontamination of Goiânia were already mentioned in the previous section. In addition, the following aspects should be emphasized:

(a) As it is not possible to train technicians in high dose areas, in the decontamination operations it is convenient to use professionals from installations where large amounts of radioactive material are handled, for example workers involved in radiation protection and maintenance of nuclear reactors and radioisotope production facilities. They are more accustomed to working in high radiation fields and usually they respect the radiation but do not have a fear of it.
(b) The use, whenever possible, of heavy machinery, such as excavators (back and front loaders/motor scraper), mechanical shovels and forklifts, in decontamination operations contributes significantly to reducing the individual doses.
(c) The selection of a site for the storage of the waste produced in the decontamination process should be done as soon as possible. A delay in this decision will cause delays in the decontamination operations, increasing the risk of the dispersion of radioactive material in the environment. The area selected should have features which will allow it to become a permanent site for the construction of waste disposal facilities in the future, in order to avoid possible transport accidents and the unnecessary exposure of personnel.
(d) It is important to include in the intervention team a group of mental health specialists to give support to the victims in hospitals, to implement a net of psychological assistance to the population and to help the professionals of the intervention team bear the stress of their jobs.
(e) To have a very well designed plan will facilitate the intervention in an accident. However, it is important not to forget certain powerful tools for confronting an unusual situation: knowledge, common sense and

creativity. An unusual emergency situation sometimes requires unusual solutions.

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CONSEQUENCES OF THE ALGECIRAS ACCIDENT, AND THE SPANISH SYSTEM FOR THE RADIOLOGICAL SURVEILLANCE AND CONTROL OF SCRAP AND THE PRODUCTS OF ITS PROCESSING

M.T. ESTEVAN
Consejo de Seguridad Nuclear,
Madrid, Spain
E-mail: mteb@csn.es

Abstract

The paper presents a case study of the consequences of the 1998 radiological accident at Algeciras, Spain, and describes the Spanish system for the radiological surveillance and control of scrap and the products resulting from its processing. Preventive measures, the Protocol for the Radiological Surveillance of Scrap and the Basic Nuclear Emergency Plan are presented, and the improvement of detection systems and the development of training and information programmes are described.

1. CASE STUDY: CONSEQUENCES OF THE ALGECIRAS ACCIDENT, SPAIN

Orphan radioactive sources could be incorporated, accidentally or intentionally, as part of scrap or metallic products to be melted in industrial processes to obtain steel, aluminium and lead, among other metals.

On 30 May 1998 such an event occurred when an orphan source of ^{137}Cs was accidentally melted in one of the furnaces of a stainless steel plant belonging to the enterprise Acerinox, S.A., in the south of Spain. This source had arrived at the steelworks as part of a consignment of scrap. It had an activity of 100 Ci[1] and had come from the United States of America via Rotterdam. The source, which had arrived by sea at the installation for recycling, had not been detected by the radiation monitor at the security check gateway at the entrance to the plant, because it was out of order.

As a result, the source contaminated the plant itself, an industrial organic waste treatment plant, an inert materials recovery centre, a truck washing facility and an experimental metallurgy plant. It also released ^{137}Cs to the

[1] 1 Ci = 37 GBq.

atmosphere via the stack, and the radioactive material was dispersed into the environment.

On 2 June Acerinox had the first indication of what had happened when, upon arriving at the installation, a lorry that usually undertook cleaning operations activated the alarm of the radiation monitor at the security check gateway at the entrance of the installation.

The Consejo de Seguridad Nuclear (CSN, the Nuclear Safety Council) was informed of the existing plant contamination on 9 June, and on that day put in motion a series of operations whose objectives were:

— To understand the situation clearly in order to put into practice measures to avoid extending the contamination and exposing people to it;
— To put in place surveillance and control of the affected installations;
— To implement dosimetric monitoring of the personnel potentially affected;
— To implement environmental radiological monitoring to evaluate the potential radiological consequences of the incident;
— To inform the local, regional, national and international authorities and the public through the communication media about the situation and the measures and operations undertaken.

On 10 June the CSN sent inspectors to all affected installations.

On the afternoon of 11 June the CSN received, through the ECURIE system of the European Commission, notification of the detection of higher than normal ^{137}Cs levels in the air in various zones in the south of France and the north of Italy, and taking into account the existing meteorological conditions on the days immediately before the detection, of the possibility that the presence of the caesium could be due to an emission that had occurred in the south of Spain or the north of Africa.

With the coincidence of what had happened in the Acerinox plant and the information coming from France and Italy, the CSN decided to take as a working hypothesis in the operations taken that the two incidents were directly related, although a clear relation between these events could not be established.

In the month of June the CSN undertook inspections and controls in the different installations affected and established a more intense programme of environmental radiological monitoring. The general public and the local, regional and national authorities were informed, and so were the IAEA, the European Commission, the OECD Nuclear Energy Agency and the regulatory organizations of France, Germany, Italy, Portugal and the USA.

On 30 June the cleanup and decontamination operations were continued under the direct supervision of the CSN. The results obtained by the environmental radiological monitor indicated the total absence of radiological risk outside the plants affected. A series of investigations to determine the activity of the source and its possible origin were put into action.

The decontamination and cleanup operations of the Acerinox plant were finalized in 2000, and the report on the residues was produced in 2001.The cost to the firm of all these operations exceeded 6 million euros.

2. SPANISH SYSTEM FOR THE RADIOLOGICAL SURVEILLANCE AND CONTROL OF SCRAP AND THE PRODUCTS RESULTING FROM ITS PROCESSING

The Spanish radiological protection authorities, along with the business associations involved in the metal recovery and smelting industry, have established a national system for the radiological surveillance and control of scrap and of the products resulting from its processing. The system consists of a set of legal bases, the installation of specific radiological surveillance equipment and the enhancement of other general purpose equipment that existed prior to these initiatives, the development of radiological training and information programmes for professionals involved in the metal recovery and smelting sectors, and the improvement of the national radiological emergency response system.

2.1. Preventive measures

For the development of preventive measures, the Ministry of Industry and Energy (MINER) and the CSN, with the collaboration of the radioactive waste management agency (Empresa Nacional de Residuos Radiactivos, S.A. (ENRESA)), the Spanish federation of recovery industries (Federación Española de Recuperación (FER)) and the Spanish association of iron and steel companies (Unión Española de Empresas Siderúrgicas (UNESID)), have implemented a national system aimed at reducing the risks posed by the presence of radioactive material in scrap. The system is structured around four actions:

— Regulation of the radiological surveillance and control of scrap;
— Installation and improvement of radiological surveillance systems;
— Implementation of radiological training and information programmes;
— Enhancement of radiological emergency response plans.

2.2. Establishment of the legal framework

The Law Governing Tariffs and Public Prices for the Services Rendered by the Nuclear Safety Council, Law 14/1999, of 5 May, modified the organization's areas of competence, assigning to it the following functions:

- *"to inspect, assess, control, report and propose to the competent authority the adoption of whatever prevention and correction measures might be required in the event of exceptional emergency situations...when such situations arise in installations, equipment, companies or activities not subject to the system of authorisations included in the nuclear legislation";*
- *"to control and watch over the radiological quality of the environment throughout the national territory...and collaborate with the competent authorities in relation to environmental radiological surveillance outside the areas of influence of nuclear or radioactive installations."*

2.3. Protocol for the Radiological Surveillance of Scrap

The Protocol for the Radiological Surveillance of Scrap is a voluntary commitment subscribed to by the MINER, the Ministry of Public Works, the CSN, ENRESA, FER and UNESID, and is aimed at establishing a national system for the prevention of risks arising from the presence of radioactive material in scrap and in the products resulting from its processing. Subsequent to signing of the Protocol, the most representative trade unions in the metal industry decided to ratify its terms.

For implementation of the Protocol, the MINER created a register including all those scrap processing installations that had voluntarily accepted its terms.

The Protocol established that the actions will be financed by the subscribing companies — except as regards the costs arising from the detection of radioactive sources of national origin, which shall be financed through the ENRESA Fund — and that the subscribing companies may pass on such costs to third parties.

The implementation of the Protocol is complemented by the development of various specific documents:

- Communication of Entry on the Register;
- Generic authorization for transfer;
- CSN Safety Guide;
- Model contract between ENRESA and the subscribing companies;
- Notification forms.

2.4. Installation and improvement of detection systems

2.4.1. Installation of specific detection systems

From the point of view of instrumentation, the implementation of the Protocol for the Radiological Surveillance of Scrap refers specifically to the installation of radiation detection systems. In general terms these systems may be as follows:

— Automatic gate monitors;
— Portable detection systems;
— Systems for γ spectrometry analysis.

2.4.2. Improvement of environmental radiological surveillance

The CSN has an environmental radiological surveillance network made up of automatic stations and a network of university laboratories, the objective of which is to maintain a permanent watch over environmental radiological quality.

The CSN network is being complemented with a new system which is less dense but which is equipped with high sensitivity apparatus designed to detect extremely low concentrations of radioactivity in the air. The detection thresholds are close to the levels of contamination that would be expected as a result of events having the characteristics of the Acerinox incident.

2.5. Training and information programmes

A training programme on radiological protection and instrumentation has been set up for the management and technical staff of steelworks and scrap storage facilities, along with an information programme for the rest of the personnel. These are made up of three levels:

— A general level on the fundamentals of radiological protection and the risks deriving from the presence of radioactive material in scrap, aimed at the management and technical staff;
— A technical level on instrument techniques and initial actions, aimed at the relevant technicians;
— An information level aimed at all personnel working in the metal smelting and recovery industries.

2.6. Enhancement of emergency plans

The Basic Nuclear Emergency Plan (PLABEN) is fundamentally oriented towards emergencies occurring at major nuclear installations, and does not specifically contemplate radiological emergencies at other facilities. With a view to covering the latter, the CSN and the Ministry of the Interior are reviewing the PLABEN, the aim being to cover a wider spectrum of emergency situations, such as the one that occurred at Acerinox.

2.7. Conclusion

The MINER, the Ministry of Public Works, the CSN, ENRESA and the business associations of the metal smelting and recovery industries have established a national radiological surveillance and control system aimed at preventing the risks arising from the presence of radioactive material in scrap and in the products resulting from its processing.

This surveillance and control system:

— Is based on a specific legal framework;
— Consists specifically of a protocol for collaboration between the companies recycling metals and the administration;
— Is complemented by a radiological training and information programme.

RADIONUCLIDE DISPERSION AND RELATED RADIOLOGICAL RISK

W. WEISS
Federal Office for Radiation Protection,
Oberschleissheim, Germany
E-mail: wweiss@bfs.de

Abstract

Since 1945 some 130 accidents with radioactive sources have been reported. In the early phase of such an accident it is important to detect, identify and locate the radionuclide dispersion and to assess the related radiological risk. Transport models and mobile systems for surveillance of the environment would be used for this purpose. Accidents with dangerous radioactive sources can lead to serious health effects for individuals of the population. In many cases of a widespread dispersion (with a length scale of a few kilometres around the point of release) of the activity of such sources, the risk to the population would be small. The release of radioactive material in an urban environment could cause great concern in the population.

1. INTRODUCTION

When radioactive sources are managed according to standards in a safe and secure manner, the radiation risks to workers and the public are minimized. If the sources are not managed appropriately, as in the case of an accident, malevolent use, or orphan sources, they can cause a range of deterministic health effects to individuals.

Radiation sources can be characterized as α, β and γ radiation sources. The radionuclides used most frequently for γ radiation sources are ^{192}Ir, ^{60}Co and ^{137}Cs; characteristic values of the activities of these sources are 10 to 100 GBq.

Since 1945 some 130 accidents with radioactive sources have been reported (IAEA, internal communication, 2003, Fig. 1); about 60% of the accidents were caused by γ radiation sources. The cases of death reported include 27 workers (β and γ sources), 33 patients (β and γ sources) and 35 members of the public (γ sources). In many cases death was caused by external exposure.

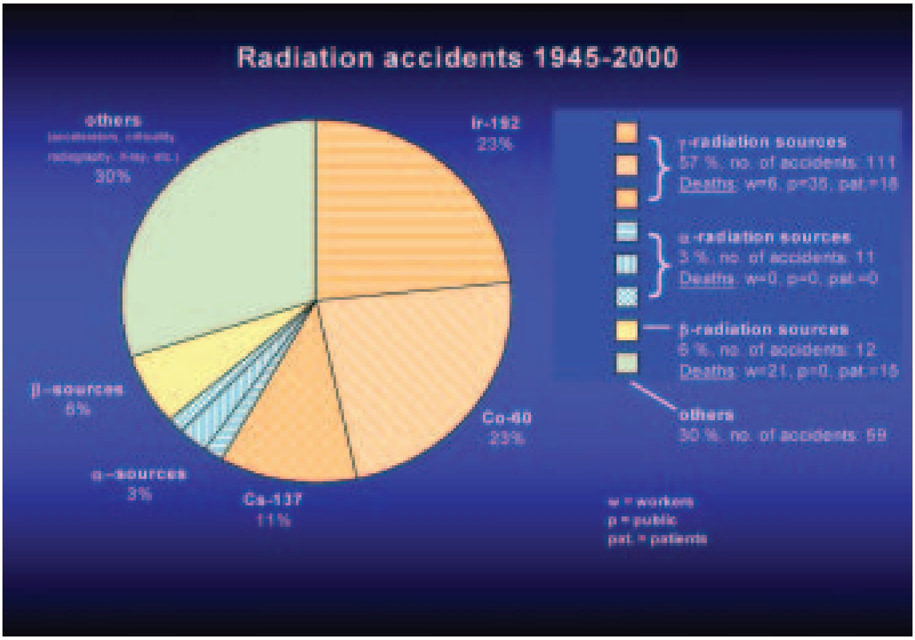

FIG. 1. Radiation accidents 1945–2000.

In the early phase of an accident that is related to radiation sources of this kind and that has a substantial impact on the environment and on members of the public, the tasks of high priority are to:

— Detect that an accident has occurred;
— Identify the relevant radionuclides;
— Locate the affected areas;
— Estimate the related radiological risks to the population;
— Establish health physics control for the population;
— Provide medical treatment to highly exposed members of the public.

Later on, in the recovery phase, the main emphasis is on restoring the situation and returning to 'normal' life. This would include a variety of actions, e.g. a thorough environmental monitoring of air, soil, vegetation and drinking water. In specific areas, remedial actions such as decontamination of property, collection of contaminated clothing, removal of contaminated soil and restrictions on the consumption of home-grown products would be required. The population should be involved in these activities.

2. ASSESSMENT OF THE RADIONUCLIDE DISPERSION AND THE ENVIRONMENTAL SITUATION

The detection and identification of an accident and identification of the relevant radionuclides can be based on a variety of state of the art technical equipment.

The most efficient way for a radionuclide to be dispersed in the environment is transport by air. The resulting contamination pattern depends on a number of parameters, the most important of which are: height of release above ground, vertical extension of the plume at the point of release, wind direction and velocity, vertical stability of ground level air and deposition velocity of atmospheric radioactivity (depending on particle size, dry or wet deposition conditions). Airborne dispersion leads to an efficient dilution of the activity per air volume. As a consequence, the radiological risk related to the contamination levels in the environment rapidly decreases with distance from the point of release. Characteristic transport velocities of a 'plume' are a few metres per second or a few kilometres per hour. As most of the radionuclides in question will be attached to aerosols, the airborne fraction of the activity will gradually be deposited on the ground. Typical deposition velocities for atmospheric aerosols are 1 to 2 mm/s.

The fast location of the affected area can be based on atmospheric transport and deposition models [1] (Fig. 2). In a complex situation such as in

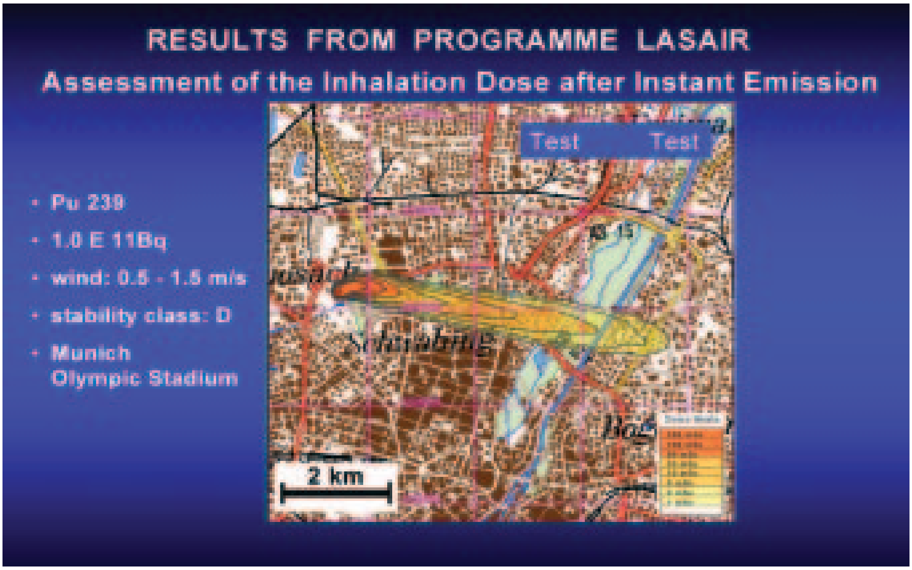

FIG. 2. Results of model predictions of the inhalation dose after a release of ^{239}Pu.

an urban environment, the required model parameters may, however, not be available with sufficient resolution (time, space) in real time, and the model predictions may therefore be an indication only of the direction and the area in which the contamination would be expected. In addition, small scale inhomogeneities of transport, mixing and deposition might result in subscale variations in the distribution of the contamination (i.e. hot spots), which cannot be resolved by a model. Such hot spots could be of particular importance for protective measures. On the basis of model information of this kind, the emergency response units would initially have to identify the affected area using a pragmatic approach. The contamination pattern and the dose by inhalation and external exposure decrease rapidly with distance from the point of release. Characteristic length scales for a decline by a factor of 10, 100 and 1000 are 900, 3000 and 6000 m. This means that urgent emergency measures could concentrate initially in the area close to the point of release.

One can think of many other dispersion patterns of radioactivity in the environment, such as the random walk type pattern reported for the Goiânia accident, which cannot be predicted by state of the art models.

In any case, a detailed assessment of the affected area can only be based on an aerial survey. For this purpose, fast airborne monitoring techniques [2] are preferable (Fig. 3). With this technique an area of 10 km × 10 km can be

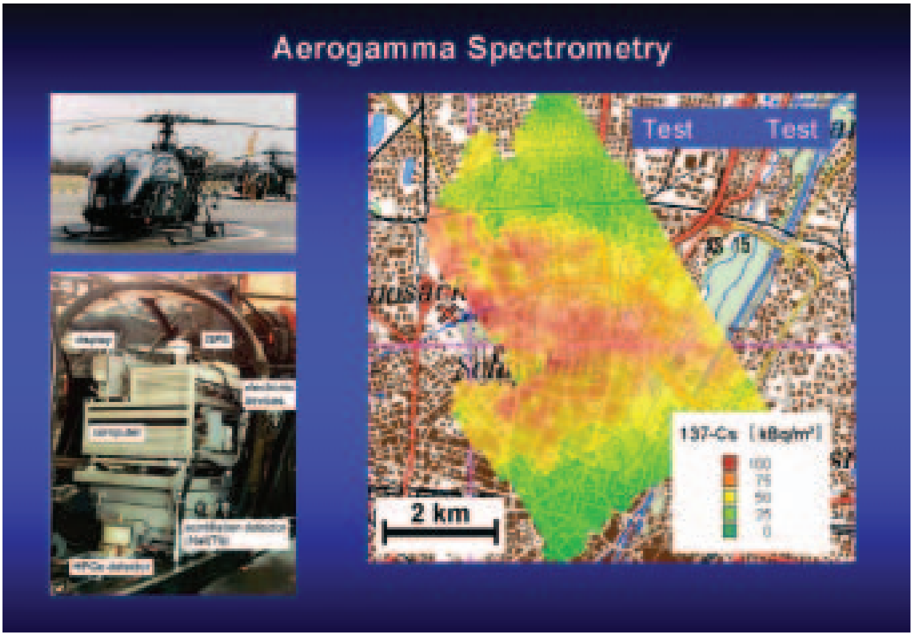

FIG. 3. Results of aerial monitoring of ^{137}Cs contamination.

surveyed in less than half a day. Individual sources with an activity above 1 (5) GBq ^{137}Cs (^{60}Co) can be detected and located with this method. The corresponding minimum value for ground depositions is 5 kBq/m². The spatial resolution of the helicopter data would be limited, for example from several hundred to more than a thousand metres. Therefore subsequent ground based surveys of such an area by cars or with handheld monitors would be required. On the basis of such a ground based survey, a more detailed assessment of the related radiological risks to the population would be possible.

3. ASSESSMENT OF THE RELATED RADIOLOGICAL RISK

The assessment of the related radiological risk can be based on the revised categorization of 'dangerous' radioactive sources [3]. This categorization is based on the potential of radioactive sources to cause deterministic effects. Stochastic effects of radiation are deliberately excluded by this categorization. The rationale behind this is that deterministic effects resulting from an accident or a malevolent act are likely to overshadow any increased stochastic risk. It is doubtful if the public perception of such an accident or act would follow this rationale. The IAEA concept of a dangerous source has been converted into operational parameters by calculating the quantity of radioactive material that could lead to severe deterministic effects for given exposure scenarios and dose criteria. The following pathways have been considered:

— An unshielded source being carried in the hand for 1 hour or in a pocket for 10 hours, or being in a room for days to weeks;
— Dispersal of a source, for example by fire, explosion or human action, resulting in a dose from inhalation, ingestion and/or skin contamination.

Reference dose values for the categorization of a dangerous source are given in Table I. These health effects of dangerous sources will be limited to highly exposed individuals. Individuals who receive doses of this order of magnitude require intensive medical treatment in specialized institutions, which may not be available in many countries. The IAEA and WHO/REMPAN [4] could provide/organize support in various ways, i.e. the expertise, infrastructure and facilities needed to cope with such a situation .

On the basis of characteristic activity values of radioactive sources, dose values of this order of magnitude are not expected for most of the members of the population in the affected area. If, for example, one assumes that a total activity of 100 GBq ^{137}Cs is dispersed in the environment by atmospheric

TABLE I. REFERENCE DOSE VALUES FOR THE CATEGORIZATION OF A 'DANGEROUS' SOURCE

Organ	Organ dose
Bone marrow	1 Gy in 2 d
Lung	6 Gy in 2 d
Thyroid	5 Gy in 2 d
Skin	25 Gy for a period of 10 h[a]

[a] At a depth of 2 cm for most parts of the body or 1 cm for the hand.

transport, the resulting activity in the air and on the ground, and subsequently the dose by inhalation and by external exposure, would be orders of magnitude lower than the values given in the table. The effective dose of a member of the public in the affected area, which would be received during the first seven days after a release at a distance of up to 1 km, can be estimated to be far below 1 mSv. This means that the radiological risks for the population on the average would be very small. Nevertheless, there would be a demand from a great number of people for individual contamination control and medical treatment. This would require the establishment of an appropriate system for contamination control and medical support.

In the near vicinity of a release point, the dose values could well exceed 1 mSv. In this case it would be a matter of a detailed monitoring survey to identify the areas with higher contamination, including hot spots, and to take appropriate measures to lower the resulting dose and risks to the population to acceptable values.

The dose received in such a scenario depends on the activity and the radionuclide of the source. If, for example, one assumes a ^{239}Pu source of the same activity as above, dose values above 100 mSv would be received at distances of less than 1 km from the point of release, mostly by inhalation. This would result in an increased risk for stochastic effects for the population in this area. According to international recommendations [5–7], emergency actions would be required in this area.

The release of radioactive material in an urban environment would cause great concern in the affected population and could lead to panic reactions in the early phase of an accident. There would be significant social, political and economic consequences associated with the return to normality of the affected local population. There would be considerable interest on the part of the media in an event of this kind.

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FUNCTIONAL REQUIREMENTS FOR PREPAREDNESS AND RESPONSE TO THREATS, THEFTS, DETECTION, INCIDENTS AND ACCIDENTS

I. USLU, E. TANKER
Turkish Atomic Energy Authority,
Ankara, Turkey
E-mail: ibrahim.uslu@taek.gov.tr

Abstract

A State should have a plan ready for response to the detection or suspicion of illicit trafficking in or loss of control of radioactive sources. The response to a radiological emergency may involve many organizations. Therefore, in order to be effective, the response to a radiological emergency must be well co-ordinated, and arrangements must be appropriately integrated with those for a conventional emergency. The regulatory body should require that the emergency arrangements be tested in an exercise before the commencement of operations.

1. INTRODUCTION

Every State needs to develop a monitoring strategy based on an assessment of the threat posed by radiation sources to the health of individuals and on an assessment of the potential economic impact of orphan sources. As monitoring systems will detect some radioactive sources, it is important that every country have a clear policy regarding the action to be taken when a radioactive source is detected. It is of considerable importance to have a mechanism whereby persons who find sources know whom to contact, and that the persons contacted are able to summon expert assistance. Also, it is considered important that appropriate training be provided to those in the response chain — for example police or customs officers — and that such training should include emergency response exercises [1].

Historically, most thefts were motivated by misguided thoughts on the part of the thieves that the stolen radioactive sources had monetary value. Such motivation for thefts continues to be valid today. Unfortunately, when thieves learn that the stolen items cannot be sold, they often discard them with trash or scrap metal, creating radiological risks for people who handle and dispose of trash or process and use recycled scrap metal. In comparison, the theft and smuggling of radioactive sources for malevolent purposes have historically been relatively rare. Even so, such activities have always been of concern to national authorities, for these incidents increase risk to the public and also create opportunities to expose people or contaminate property [2].

In the event of a radiological emergency, the time available for decision making and for implementing an effective strategy of response may be short. All organizations that may be involved in the response to a radiological emergency should be prepared for such events and need to co-ordinate their efforts during the emergency [3].

2. EMERGENCY PREPAREDNESS AND RESPONSE

The practical goal of emergency preparedness may be expressed as: to ensure that arrangements are in place for a timely, managed, controlled, co-ordinated and effective response to any radiological emergency at the site and at the local, regional, national and international level. In taking measures towards achieving this goal, justification of intervention and optimization of intervention principles have to be applied at all times [4, 5].

The practical objectives of emergency response during a radiological incident are to:

(a) Take mitigatory action at the site;
(b) Prevent the occurrence of deterministic effects in workers and the public;
(c) Render first aid and manage the treatment of radiation injuries;
(d) Reduce the occurrence of stochastic effects in the population;
(e) Limit the occurrence of non-radiological effects in individuals and in the population [2, 3, 6].

Circumstances requiring response include:

(a) Detection, through radiation monitoring, of the unauthorized or uncontrolled presence or movement of radioactive sources;
(b) A report of radioactive sources having been found in an unauthorized location;
(c) A report of an object suspected to contain radioactive sources;
(d) A report of an accident involving, or suspected to involve, radioactive sources;
(e) A report of instances of non-compliance with the transport regulations for radioactive material;

(f) Discrepancies found in an inventory of radioactive sources;
(g) A report of an illicit transboundary movement of radioactive sources (Ref. [3], p. 83).

The emergency response plan should cover the following:

(a) Whom to notify (customs officials, law enforcement officials, emergency response units, etc.);
(b) What information should be supplied to aid the recovery of control;
(c) Measurements to be made for detection and analysis;
(d) Temporary storage arrangements for any radioactive source that might be found;
(e) Arrangements for transport to a final authorized storage or disposal facility;
(f) Information needed for alerting and informing the public about lost or illicitly moved radioactive sources [2, 6].

A classification system should be established with the aim of initiating a sufficiently rapid response to allow for the effective management and implementation of emergency operations. Within the classification system, each emergency class should represent circumstances that pose approximately the same level of risk and prompt approximately the same level of response [1].

3. ASSESSMENT OF THREATS

During an assessment of a radiological threat, facilities, sources, practices, on-site areas, off-site areas and locations should be identified for which a radiological emergency may warrant:

(a) Precautionary protective actions for keeping doses below intervention levels, in order to prevent severe deterministic health effects.
(b) Urgent protective actions for averting doses, in order to reduce stochastic effects.
(c) Countermeasures related to the food chain and for longer term protective measures.
(d) Protective actions for the responding workers. Locations at which there is a significant probability of encountering a dangerous source that has been lost, abandoned, illicitly removed or illicitly transported should also be identified in the threat assessment [1].

4. IDENTIFYING, NOTIFYING AND ACTIVATING

4.1. Preparation

Notification points responsible for receiving (e.g. through a toll free telephone number) emergency notifications of an actual or potential radiological emergency should be established. In jurisdictions where there is a high probability of encountering a dangerous source, arrangements should be made to ensure that on-site managers of operations and local officials responsible for response are aware of the indicators of a potential radiological emergency, and of the appropriate notifications and other immediate actions warranted when such an emergency is suspected [1].

The State should make arrangements for promptly notifying, directly or through the IAEA, and for providing relevant information to, those States that may be affected by a multinational emergency. The State should have arrangements for promptly responding to requests from other States or from the IAEA for available information regarding a multinational emergency [1].

4.2. Response

When circumstances necessitate an emergency response, operators should promptly determine the appropriate emergency class or the level of emergency response and should initiate the appropriate on-site actions. The operator should notify and provide updated information to the off-site notification point. Upon notification of a radiological emergency warranting an off-site response, the off-site notification point should promptly notify all appropriate off-site response organizations. Upon notification, the off-site response organizations should promptly initiate the preplanned and co-ordinated response appropriate to the emergency class or the level of emergency [1, 7, 8].

In the event of a multinational emergency, the States should act according to the plan developed at the preparation stage.

5. PROTECTING EMERGENCY WORKERS

5.1. Preparation and response

The police, firefighters, medical personnel, radiation specialists, radiation protection officers, radiological assessors, and drivers and crews of evacuation vehicles should be designated as emergency workers [1]. National guidance, in compliance with international standards, should be adopted for managing, controlling and recording doses received by emergency workers [9]. This guidance should include default operational levels of dose for different types of response activities, stated in units that can be directly monitored during the performance of these activities.

6. ASSESSING THE INITIAL PHASE

6.1. Preparation

Operators of practices or sources should make arrangements to:

(a) Characterize the extent and significance of any abnormal exposures or contamination;
(b) Initiate immediate corrective and protective actions on the site;
(c) Identify members of the public potentially exposed;
(d) Communicate the extent of the hazard and the recommended protective actions to the appropriate off-site response organizations.

Arrangements should be made for promptly assessing any radioactive contamination, releases and doses, in order to determine or modify urgent protective actions following a release. This capability should include arrangements for promptly conducting environmental monitoring and monitoring of contamination on people (e.g. evacuees) within the zones, and designated trained teams and instrumentation should be available. Arrangements should be made to ensure that relevant information is recorded and retained for use during the emergency, in evaluations conducted following the emergency, and for long term health monitoring of emergency workers and members of the public [1, 9].

6.2. Response

The magnitude and likely development of hazardous conditions should be appraised initially and throughout the emergency, to identify new hazards promptly and to refine the strategy for response. Information about emergency conditions, emergency assessments and protective actions, recommended and taken, should be promptly made available to all relevant response organizations throughout the period of the emergency [1, 10].

7. MANAGING MEDICAL RESPONSE

7.1. Preparation

Arrangements should be made for medical personnel, both general practitioners and emergency staff, to be aware of the medical symptoms of radiation exposure and of the appropriate notification procedures and other immediate actions warranted when a radiological emergency is suspected. Arrangements should be made at the national level for the identification, tracking and long term medical monitoring and treatment of exposed or contaminated individuals and those who are at risk [1].

7.2. Response

The medical personnel who recognize symptoms of radiation exposure should notify the appropriate notification point and should take response actions as appropriate.

8. KEEPING THE PUBLIC INFORMED

8.1. Preparation and response

Arrangements should be in place for:

(a) Providing useful, timely, truthful, consistent and appropriate information to the public in a radiological emergency;
(b) Responding to incorrect information and rumours;
(c) Responding to requests for information from the public.

The operator, other response organizations, neighbouring States and the IAEA should make arrangements for co-ordinating the information made available to the public [1, 9].

9. LONGER TERM PROTECTIVE MEASURES

9.1. Preparation and response

National intervention levels and action levels [11] for agricultural countermeasures, countermeasures against ingestion and long term protective actions should be established. Arrangements should be made for taking effective agricultural countermeasures, including restriction of the consumption, distribution and sale of locally produced foods and agricultural produce following a release. Within the emergency zones, arrangements should be made for monitoring the contamination levels of vehicles, personnel and goods moving into and out of the contaminated areas to control the spread of contamination [1, 10].

10. MITIGATING THE NON-RADIOLOGICAL CONSEQUENCES

10.1. Preparation and response

Organizations having jurisdiction within the emergency zones should make arrangements for justifying, optimizing and authorizing different intervention levels or action levels following an event for which agricultural countermeasures or long term protective actions are in place. The process should include arrangements for consulting the people affected. Anxiety or distress caused, economic conditions, including employment and long term needs for social welfare, and other non-radiological effects of long term protective actions should be considered [1].

11. CONDUCTING RECOVERY OPERATIONS

11.1. Preparation and response

For transition from emergency phase operations to routine long term recovery operations the following arrangements should be made:

(a) Definition of the roles and functions of organizations;
(b) Methods of transferring information;
(c) Methods to assess radiological and non-radiological consequences;
(d) Methods to adjust mitigating actions.

These arrangements should be implemented in an orderly manner and in accordance with international standards and guidance.

12. CONCLUSION

All those involved with radioactive sources — suppliers, manufacturers, distributors, users, transporters, waste disposal facility operators, and national and international safety, customs and police authorities — have a responsibility to apply their knowledge to enhance public and environmental safety and security. To deal effectively with a radiological emergency, planning and preparation are essential. Satisfactory response to such emergencies requires co-ordinated efforts by many national and international organizations, with the responsibilities clearly specified and adequate resources allocated.

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PLANNING THE RESPONSE TO AN EMERGENCY ARISING FROM THE MALEVOLENT USE OF RADIOACTIVE SOURCES. INFRASTRUCTURE ISSUES: ADMINISTRATIVE, TECHNICAL, PHYSICAL AND LEGAL

I. OTHMAN
Atomic Energy Commission,
Damascus, Syrian Arab Republic
E-mail: atomic@aec.org.sy

Abstract

The paper discusses the actions to be taken and the regulations required to combat and protect against the malevolent use of radioactive sources. It also highlights the administrative, technical, physical and legal functions that are important for an infrastructure for responding to an emergency involving the malevolent use of a radioactive source.

1. INTRODUCTION

Various types of radioactive sources are in use worldwide in medicine, agriculture, industry and research, and accidents or incidents are daily possibilities. This paper discusses the infrastructure required to protect against malevolent use of radioactive sources. Regulations and operational measures need to be established in all States in conformity with international standards. The aim of administrative, technical, physical and legal actions is to control any unauthorized movement of radioactive sources that may threaten the safety of the public or contaminate the environment.

The magnitude and severity of the effects of a malevolent use of a radioactive source are dependent on the effectiveness of the emergency response plan and on the infrastructure available in a State or the region that the State is in.

2. ADMINISTRATIVE PREPAREDNESS

The responsibility for dealing with the consequences of the malevolent use of radioactive sources will rest mainly with the appropriate competent authority, which has to be defined clearly in an emergency response plan. This plan should also indicate the responsibility and functions of the various authorities within the country (e.g. the local authorities, police, fire brigade, medical services, national defence) to be notified if such a use occurs.

The organization established to deal with accidents involving radioactive material can also be responsible for combating the malevolent use of such material, while the licensee and local authorities should be responsible for the safe storage and transport of radioactive sources. Ambiguities in the responsibilities of organizations need to be resolved and the responsibilities must be stated clearly in an emergency plan.

The communication and notification system available in the event of an accident can be utilized during a case of malevolent use; however, clear instructions need to be given.

It is not cost effective to have available separate resources, including human resources, ready for use in the event of a malevolent act. Thus it is necessary to provide information and education to all relevant personnel on how to implement the emergency plan.

The competent authority needs to identify the appropriate organizations in the States concerned that will respond in the event of a malevolent act. The planning for response will need to identify those groups within these organizations that can be mobilized for any such response, and the organizations should be part of the planning process. They will need to determine which resources their organizations should have that may be useful in responding to a malevolent act. Co-ordination in the development of their plans is necessary among the different organizations.

It is important to establish liaison with the authorities in relevant countries to be notified in an emergency, especially when the consequences of a malevolent act may extend beyond national borders.

Provision for co-ordination should be made in the emergency plan for the following:

(a) Radiological emergencies in foreign States that have a potential impact on the home State;
(b) Domestic radiological emergencies that will have consequences in another State;
(c) Requests for radiological assistance.

3. LOGISTICAL SUPPORT AND FACILITIES

3.1. Technical issues

Whenever a malevolent use of radioactive sources is suspected or reported, it is important to evaluate the situation with regard to:

(a) The extent of contamination;
(b) Neutron exposure (if any);
(c) The level of radiation exposure;
(d) Contamination of the environment.

Each group responsible for carrying out a particular function (e.g. physicists, rescue services, emergency room physicians, nurses) needs to refer to the set of standing orders given in the emergency plan.

The purpose of surveying and monitoring after a malevolent use of a radioactive source is to provide timely information on the basis of which decisions can be made to initiate protective actions. This requires the detection of an abnormal release of radioactive material and rapid determination of the type and quantity of the release. Monitoring techniques need to be appropriate to the situation, which may be, for example, dispersal of radioactive material or the theft of a radioactive source.

In many cases the same instruments used for routine work may serve in an emergency situation. However, it should be noted that access to these instruments might be limited by high radiation fields or the instruments may themselves become contaminated; it is therefore important that other suitable instruments be available. It has to be recognized that radiological measurements need a degree of skill, knowledge and experience not possessed by people who have not been properly trained.

In the event of a dispersal of radioactive material, as a minimum the following types of measurement need to be taken:

(a) Measurements of radiation fields, using portable instruments;
(b) Measurements of area contamination, using smear tests or portable radiation monitors;
(c) Measurements of air contamination;
(d) Monitoring of personnel.

It will be more difficult to perform measurements in the event that an incident involves lost or stolen radioactive sources, as the location of the sources will be unknown. A preliminary rough survey of the areas where the sources are suspected to be is advisable in such circumstances. The method to be used in performing such monitoring will depend upon the circumstances. A detailed search should not begin before the relevant area is identified. The main difficulty that will be encountered in monitoring for lost sources is that in many cases the source will be within its container, which should be borne in mind when selecting the monitoring instruments to be used. After the source has been located and retrieved, the area where it was found should be checked for possible contamination.

As a guide, the following equipment should be available for the purposes of detection and radiation surveying in the event of a malevolent use of radioactive sources:

(a) Instruments for measuring both β and γ radiation and for measuring only γ radiation;
(b) Equipment to collect high volume air samples;
(c) Containers to collect food, water, vegetation and other environmental samples;
(d) Radio communications;
(e) Personnel protective equipment and personnel dosimeters;
(f) Decontamination equipment and materials;
(g) Placards, marking line or tape and suitable materials to mark surveyed areas;
(h) Lights for operations at night;
(i) Notebooks, maps, pencils, etc.

3.2. Physical issues

Physical protection against sabotage, which may lead to the malevolent use of radioactive sources, is dependent on a mixture of the use of security devices, procedures and facility design. The physical protection system should prevent or delay access to or control over a nuclear facility or nuclear material through the use of a set of protective measures.

Safety specialists, in close co-operation with physical protection specialists, should evaluate the consequences of a malevolent act, considered in the context of the State's design basis threat, and identify nuclear material and the minimum complement of equipment, systems and devices required for protection against sabotage.

It is advisable that States seek the assistance of the IAEA's International Physical Protection Advisory Service to help in strengthening and enhancing the effectiveness of the States' physical protection system.

4. LEGAL ISSUES

More than half of the world's States have an inadequate regulatory system. The IAEA, through its project to upgrade radiation protection infrastructures, has provided support to many of these States to establish such a system, establish a regulatory authority and approve a law on radiation protection.

In addition to physical protection, legal penalties for a malevolent use of radioactive sources are required. The law of a State should consider the deliberate use of radioactive sources to harm people or the environment a crime, and the punishment should be proportional to the degree of risk posed by the crime.

The environment laws of the United Arab Emirates and the Syrian Arab Republic contain the provision of the death penalty on those importing radioactive waste, whatever the form of the waste; such provisions will certainly prevent anyone, for whatever reason, from illegally dealing with radioactive sources.

In the United States of America, legislation with more broad objectives, known as the Nuclear and Radiological Terrorism Threat Reduction Act of 2002, has been submitted to the Senate. This legislation addresses many items, ranging from the establishment of a network of regional repositories around the world to provide for the secure temporary storage of unwanted, unused, obsolete and orphan radioactive sources, to the establishment of a special representative in the Department of State for the negotiation of international agreements that ensure the inspection of cargoes of nuclear material at ports of embarkation.

Such a bill is expected to encourage the development of alternative methods to replace the radioactive sources currently used in many applications. It cannot be expected that all countries will draft similar bills; however, they could address in their radiation protection law the safety and security of radioactive sources.

5. TRAINING, DRILLS AND EXERCISES

Training personnel in the competent authority and the other organizations involved in an emergency plan is important to ensure that they have the requisite knowledge, skills, abilities, equipment, procedures and other arrangements to perform their assigned response functions.

Exercise programmes, if conducted, will ensure that all functions required to be performed for emergency response to a malevolent use of radioactive sources and all organizational interfaces for facilities are tested at suitable intervals.

The performance of drills and exercises should be evaluated against established response objectives that demonstrate that the identification, notification, activation and implementation of initial response actions can be performed in time to achieve the practical goals of emergency response.

6. QUALITY ASSURANCE PROGRAMME

Authorities and organizations involved in responding to a malevolent use of radioactive sources should establish a quality assurance programme, in compliance with international standards, to ensure a high degree of availability and reliability of all the supplies, equipment, communication systems and facilities necessary to perform the functions specified in an emergency. This programme should include arrangements for inventories, resupply, tests and calibrations, to ensure that these items and facilities are continuously available and functional for use in an emergency. Provision should be made to maintain, review and update emergency plans, procedures and other arrangements and to incorporate lessons learned from research, operating experience and emergency drills and exercises.

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INTERNATIONAL CO-ORDINATION OF RESPONSE

F. UGLETVEIT
Norwegian Radiation Protection Authority,
Østerås, Norway
E-mail: finn.ugletveit@nrpa.no

Abstract

Radiological emergencies, including those resulting from the use of radioactive substances with malevolent intent, are emergencies of international concern, and often authorities in many countries need to assess them and consider the actions to be implemented. It is therefore important for responsible authorities to prevent such emergencies and to mitigate the consequences when they do occur. It is also important to realize that these emergencies cannot be dealt with only at the national level, but need to be responded to at the international level. Through international co-operation, the international community can establish better and more cost effective mechanisms for prevention of and response to such events. All States should therefore endorse ongoing activities in this field and enhance their joint efforts to develop such mechanisms and to implement them.

1. INTRODUCTION

Radiological emergencies, including those resulting from the malevolent use of radioactive sources and potential emergencies in the form of lost or stolen sources, are events of international concern, as the radiological, and especially the non-radiological, consequences could be severe.

It is the task of the responsible authorities in all States to:

— Protect life, health and the environment; limit non-radiological effects; and prepare for the resumption of normal social and economic activity.
— Provide adequate and timely information to the public.

This is achieved through:

— Preventing emergencies from occurring
  • Enforced legislation;
— Minimization of the consequences if an emergency occurs
  • Emergency response procedures
  • Sound procedures for public information.

It is important to emphasize prevention, but we also need to realize that in spite of all efforts, radiological emergencies will happen. Besides, there are probably thousands of sources out of administrative control worldwide. It is therefore important for responsible authorities to establish systems of response to such emergencies in order to be able to handle them whenever necessary.

2. RESPONSE REQUIREMENTS

Authorities in all States need to incorporate both the above mentioned responsibilities into legislation, plans and procedures in order to minimize the probability and the consequences of such events. It is also recognized that all States depend upon each other, as misconduct in one State may end up as an emergency in another State, requiring response there. It is therefore essential that the security of radioactive sources and the response to radiological emergencies not be considered just as a national problem. They need to be considered as an international problem that has to be solved through international co-operation.

In responding to radiological emergencies of any kind, it is recognized that:

— It is the responsibility of authorities in the respective States to respond.
— Handling these events may require actions to be taken in several (or even many) States.
— Handling these events in a State may require resources exceeding the capabilities of that State.

In order to be able to make their assessments and decide upon their response, authorities need:

— Information,
— Resources.

In order to be able to respond to emergencies or potential emergencies in the best possible way, States should establish mechanisms of co-operation in line with the recommended vision established in Oslo in May 2002 at a Meeting of Competent Authorities under the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency and the Convention on Early Notification of a Nuclear Accident:

VISION

The presumed goal for the international community should be a self-sustaining and continuously improving system of co-operative arrangements between States for preparedness to respond to nuclear and radiological emergencies, so that in spite of the fact that they are individual States undertaking actions for their own population meeting their own national legal requirements, they can through co-operation, communication and sharing of information, resources and experience, achieve a coherent and globally optimized handling of the event taking all available resources into consideration.

With the adoption of such a vision, the Member States of the IAEA could establish a better and common long term planning and implementation process for themselves and the IAEA Secretariat.

3. WHAT DO WE NEED?

In order to achieve this, Member States of the IAEA need to take on this responsibility and develop mechanisms ensuring:

(a) Establishment of a strong commitment from Member States to promptly share all relevant information regarding emergencies or situations that could lead to emergencies within other States;
(b) Development of adequate standard procedures for ensuring prompt and reliable communication of this information;
(c) Establishment of a strong commitment from Member States to share resources for the assistance of other States;
(d) Development of adequate standard international procedures for response in order to facilitate assistance.

4. WHAT DO WE HAVE?

The Convention on Early Notification of a Nuclear Accident (1986) describes the obligation to notify potentially affected countries and the IAEA Secretariat of "any accident involving facilities or activities of a State Party or of persons or legal entities under its jurisdiction or control from which a release of radioactive material occurs or is likely to occur and which has resulted or may result in an international transboundary release that could be of radiological safety significance for another State". The two main limitations of this Convention relating to mandatory notification and information exchange are thus:

(a) Application only to domestic accidents involving facilities under a State's own jurisdiction;
(b) Application only to transboundary releases of radiological safety significance in another State.

The ENATOM arrangements established by the IAEA Secretariat have, however, introduced mechanisms for notification and information exchange for any kind of scenario irrespective of cause and consequences. These are, however, at present voluntary arrangements.

The Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (1987) describes the intent of the contracting Parties to assist each other in the case of a nuclear or radiological emergency and the general rules under which the assistance is requested and offered. There are no binding obligations for the States Parties to offer assistance but the IAEA Secretariat has been assigned some responsibilities.

INES/NEWS has been established at the IAEA Secretariat as a voluntary reporting and information exchange system for nuclear accidents and radiological emergencies.

The Illicit Trafficking Database has been established by the IAEA as a voluntary reporting system for illicit trafficking of fissile and radioactive material.

5. WHAT DO WE NEED TO DO?

In order to be able to achieve the goals of the proposed vision, the Member States of the IAEA need to considerably enhance their efforts, improving the international co-operation on response to radiological emergencies. Member States have so far not been able to establish a proper and cost efficient implementation of the Conventions on Assistance and Early Notification. In particular, the States Parties could realize a significant benefit from improving the implementation of the Assistance Convention.

(a) Member States need to review the legal framework and propose ways of improving the co-operation mechanisms, ensuring more binding commitments from Member States to provide adequate and timely information to other Member States on any event that has developed into an emergency or could develop into one. Interim mechanisms need to be considered as such changes are expected to take some time to accomplish.

(b) Member States need to improve and standardize procedures for communication of information, and to establish a better common communication platform upon which international and national communication can be properly achieved.

(c) Member States need to improve mechanisms for assistance in such a way that States are more willing to commit themselves to providing assistance to other States if so requested. The Convention on Assistance should be reviewed and possible ways of strengthening the assistance mechanisms explored. Interim solutions need to be considered as these types of changes might take some time to accomplish.

(d) Member States need to establish improved and standardized international procedures for response to emergencies in such a way that the assistance offered is compatible with the assistance requested.

(e) Member States need to decide on mechanisms for funding these enhanced activities and make sure that the long term sustainability required for this kind of development is achieved.

(f) Member States need to endorse and implement these improvements of international co-operation and streamline their national procedures in this respect.

(g) Member States need to enhance the IAEA Secretariat's activities in co-ordinating this development work.

(h) The IAEA Secretariat should streamline its response to emergencies, in particular the collection and dissemination of information and the co-ordination of assistance.

Many of these activities are already in progress or are being planned by the IAEA Secretariat and competent authorities under the Conventions on Assistance and Early Notification. At the second Meeting of Competent Authorities under the Conventions on Assistance and Early Notification, scheduled for June 2003, an action plan for enhancing international co-operation on response to nuclear and radiological emergencies will be discussed and hopefully endorsed.

6. CONCLUSIONS

We clearly recognize that enhancing the mechanisms of international co-operation on response to nuclear and radiological emergencies would significantly improve Member States' capabilities for responding to such emergencies and make them more cost efficient. Member States should therefore follow up on IAEA General Conference Resolution GC(46)/RES/9 and enhance their efforts to improve their national capabilities, implementing international standards and recommendations and taking part in the further development of international co-operation on response to nuclear and radiological emergencies.

The most important unsolved problem in achieving the enhancement of international co-operation in this field is the issue of funding. Member States need to find better ways of funding this international co-operation between them and the sustainable development of mechanisms and procedures.

PANEL DISCUSSION 3

PLANNING THE RESPONSE TO RADIOLOGICAL EMERGENCIES ARISING FROM THE MALEVOLENT USE OF SOURCES

Chairperson: **S.H. Na** (Republic of Korea)

Members: **M.T. Estevan** (Spain)
I. Othman (Syrian Arab Republic)
F. Ugletveit (Norway)
I. Uslu (Turkey)
L. Vinhas (Brazil)
W. Weiss (Germany)

KIM SEON BIN (Republic of Korea): First, I would like to raise the question of how to prevent the malevolent use of the radioactive sources which are frequently and widely used for non-destructive testing (NDT) in industry. The second comment is on public sensitivity concerning radioactive sources. In the Republic of Korea, 12 cases of theft have been recorded in the area of NDT. Three of them, involving sources stolen before 1985, are still unsolved, and in the other nine cases, the sources were recovered. Overexposure from those sources has not been reported but it is obvious that each incident may raise serious concerns about the safety and security of radioactive sources. Many of these incidents occurred because of ignorance of procedure, and others were a consequence of poor training and working conditions with night shifts. In the Republic of Korea, thousands of high activity sources are in circulation and around 2500 radiation workers are doing NDT jobs at night. Such conditions favour the occurrence of incidents such as theft or loss of sources and terrorism, even though extensive safety and security measures are taken. In this regard, I would like to propose more international effort or initiative action to reduce the risk of the malevolent use of radioactive sources.

S.H. NA (Republic of Korea): The issue of public awareness will be dealt with in the next session. I ask Mr. Uslu to answer the question about preparedness for emergency response.

I. USLU (Turkey): I have mentioned an IAEA TECDOC to be published this year that contains information on preparedness for radiological dispersal devices (RDDs) and refers to NDT sources. I can give you the relevant pages from the draft document. In Turkey, we advise the public through the media to call a three digit telephone number operating around the clock if they find any sources. All NDT companies should have their personnel trained on-site and should be certified by the Turkish Atomic Energy Authority. This on-site training focuses on preparedness for and response to radiological accidents. After this certification, we urge them to prepare emergency response plans.

S.H. NA (Republic of Korea): Mr. Uslu emphasized the emergency contact point and training and education.

R. DOS SANTOS (Brazil): Could Mr. Vinhas mention something about the costs involved in responding to the Goiânia accident?

L. VINHAS (Brazil): The direct cost of the accident was around US $16–17 million distributed more or less in the following way: $7–8 million for mitigation and cleanup activities and around $8 million for repackaging containers and constructing final repositories. Around 700 persons were involved in the cleanup operation.

K.S. PRADEEPKUMAR (India): Lessons from Goiânia or other radiological accidents can be a guidance for preparedness and response to emergencies following radiological terrorism, but I believe we should not underestimate the problem of contamination of injured persons if radioactive sources are blasted out in a terrorist activity. The exposure can be many orders higher than that received by external exposure and inhalation, as the blast can force the activity into people's bodies and into surrounding buildings. Also, fire could spread radioactivity to people and materials. Severely contaminated persons may require urgent medical intervention, which requires special attention of hospital staff, so hospital availability and the protection of hospital staff also need special attention. As firefighters and police may be rushing to the blast site, they may have to be provided with monitoring instruments.

S.H. NA (Republic of Korea): You raised the concern of external contamination and medical response. Would Mr. Weiss like to comment?

W. WEISS (Germany): I completely agree that there are a wide variety of risks associated with sources. I mentioned two radionuclides, caesium and plutonium, and their different rates of toxicity, so to cope with an unknown situation, you have to assume that the full spectrum could be present and could contaminate by inhalation or through wounds, which could seriously affect the health of individuals. The REMPAN network of the World Health Organization was established to cope with situations like this. It could provide help to individuals, though not to great numbers of people, and give them state of the art treatment, but we have to accept that there are doses which cannot be treated.

M.T. ESTEVAN (Spain): I would like to add that when dealing with this kind of contamination and the affected persons (here prevention would be best), it is most important to have an emergency preparedness plan. Emergency planning exists for nuclear power plants but emergency preparedness for dealing with radioactive sources is less structured. An emergency plan should include a reference hospital, which we have in Madrid. Any radiation victim would be immediately transferred to it by helicopter. If you do not want to have to improvise, you must have a very detailed emergency plan prepared to deal with any kind of source, be it in hospitals, in industry, in research, in laboratories or in nuclear power plants. We have seen through the comments by the IAEA that the major problem of Chernobyl was the lack of an emergency plan. Therefore we should all try to get our emergency preparedness into as good a state as possible.

S.H. NA (Republic of Korea): Another idea is to train medical responders at a specialized hospital, and then when an accident happens in the region, local hospitals can liaise with the central hospital.

M. TOMAK (Turkey): I suggest a benchmarking study with the aim of compiling a practical list of best practices. This applies to everything we have discussed at the conference and could aim at generating action.

M. CRICK (IAEA): The IAEA convened a meeting about two years ago where we tried to pull together lessons learned from a lot of these source type emergencies. Although there had not been any malevolent attacks, we certainly described the response to these rather infrequent radiological emergencies and put the lessons learned into practical technical documents, which I think many of you have probably seen. We are about to reissue the latest lessons learned, which will provide a useful set of checklists.

A. NILSSON (IAEA): I would like to ask for panel members' views on the fact that there are some new areas opening, in particular at the stage where an emergency situation could develop. In our programme, we often refer to this stage as pre-emergency, which involves a number of players other than the usual ones. While it is absolutely clear that certain response actions are needed for an emergency situation arising from an RDD, we also need to prepare for what precedes that. For instance, what is to be done when we have a report of a theft or when we know that something is on the move? This is a new, challenging situation. I would appreciate your comments on urgent actions for such a pre-emergency.

M.T. ESTEVAN (Spain): It is extraordinarily important to have pre-emergency planning and prevention. Since 11 September 2001 and the appalling events in the United States of America, all nuclear power plants in Europe and in the USA have taken pre-emergency measures for physical protection. An intrusion or any other kind of accident has to be foreseen, not just the consequences dealt with. The State security authorities, in order to localize the sources, accidents and persons in question, have to be properly trained, and therefore this aspect of training is of the utmost importance.

Moreover, pre-emergency as well as emergency planning have to be properly designed and incorporated into the appropriate overall plans, because when the situation arises, the first reaction is one of great distress and confusion. Therefore we are currently working harder on pre-emergency preparedness and prevention than we are on actual physical protection.

I. OTHMAN (Syrian Arab Republic): Malevolent acts constitute a new area that we have been dealing with since 11 September 2001. However, do we need to allocate a lot of resources for cases which, seen in the context of all radiological accidents, form a very small proportion? We cannot set up a complete system pertaining only to malevolent use. I think it would be a good idea to merge emergency plans for accidents, paying special attention to those involving malevolent use. I don't think anybody has really studied that in detail. The proposal of benchmarking on this issue could help in solving such problems and could introduce new ideas for pre-emergency or emergency response to accidents involving malevolent intent.

S.H. NA (Republic of Korea): This new area is very important. Also, the barrier of lack of experience has to be removed. Comments by panelists and from the floor recognize that the initial stage of a radiological emergency involving malevolent intent is important.

J.P. INDUSI (USA): There is certainly interest in security here but the accidents that were described are very regrettable. The question would be for Mr. Vinhas from Brazil or others who would like to comment. Would a durable marking or some symbol have made any difference, and what would his advice or position on this be?

L. VINHAS (Brazil): The public should be informed about radiation. For instance, in Goiânia, if someone had recognized the radiation symbol, probably the accident could have been avoided. It is important to have a decentralized system to make the first response to an emergency. In Brazil, we have compiled a document listing all sources used in the country, with photos of the equipment containing the sources, and describing initial response measures to take in an emergency. We distributed this document to all health organizations in the country, and to provincial and municipal authorities. This makes it possible to reduce the area affected and to expedite the response. At the same time, it helps to avoid false alarms. After the Goiânia accident, we had a large number of them. Anything strange or suspicious was perceived as a nuclear accident, which created a terrible situation of panic and uncertainty.

I. USLU (Turkey): The radioactivity sign was one of the reasons for the Istanbul accident. The scrap dealers thought that the container held something valuable, so they started to open it and then the accident happened. After the accident report was issued, the Turkish Atomic Energy Authority urged that the radioactivity sign be revised, and I also mentioned this at the Buenos Aries conference. I am very pleased that the IAEA is revising this radioactivity sign and also that it will be tested all over the world — even on some very uneducated people — and that a new sign should appear next year. This could prevent many accidents.

D. SUBASIC (Croatia): I would like to comment on the use of the radiation sign — as we had in Croatia during the war — for lost or orphaned sources. We tried to make it publicly known that under the rubble of buildings destroyed by war operations there could be radiation sources, and that if people went into a war damaged building, they risked radiation exposure, particularly if they saw equipment marked with a trefoil sign. And then, on the spot, we tried to alert the general public, in particular kids, who might be trying to find something of value in destroyed buildings, that there was a risk. So I would say generally that, depending on the accident, sometimes the radiation sign could be very useful and could help to prevent an accident. However, I also understand that it could lead to misinterpretation and to panic, which was sometimes the case in Croatia.

S.H. NA (Republic of Korea): This is a little outside the scope of the topics discussed in this panel. Moreover, awareness will be discussed in the next session.

A.J. MATEO (Philippines): In August 2001, a licensee reported the theft of a nuclear moisture density gauge. We undertook an investigation with assistance from the police authorities, who verified that the gauge had really been stolen. We issued press releases, and also involved radio and TV, making announcements about the radiological consequences if such a gauge were to be dismantled, possibly by the perpetrators. Up to now we have not been able to locate the gauge. Now my question is: Should there be a time frame for completing our activities, after which we would stop trying to locate this stolen source?

M.T. ESTEVAN (Spain): We were told yesterday that the European Union was missing 30 000 orphan sources, and undoubtedly there have been other cases in Spain involving orphan sources in scrap. For example, you heard about what happened to us. This was negligence, it was not malevolence, but you still have the same problems when dealing with scrap to ensure security.

S.H. NA (Republic of Korea): I have a correction by the European Union pertaining to the number 30 000. This is the number of sources stored by end users, not the number of lost sources.

L. VINHAS (Brazil): It is good practice to inform the press about such things, but usually, if the source has been stolen, when you announce it to the press and if the thief has malevolent intent, the source will be discarded at the first opportunity, and it will be quite difficult to recover. This happened in

Brazil, and fortunately the police recovered the source. We went two or three times to the police office to collect sources for secure storage.

I. USLU (Turkey): In France, for example, to keep sources traceable, they stipulate that after ten years of useful life, sources — especially nuclear gauges, for example — are assumed to be spent. Still, a company may apply to the French authorities to extend a source's useful life for up to ten years. This is also a solution.

I. OTHMAN (Syrian Arab Republic): We have to distinguish between orphan sources and those sources stolen for malevolent use. In my opinion, physical protection measures are the most important means for ensuring the security of sources. Theft is the main issue now. To prevent an act of terrorism, physical protection measures have to be in place, though not necessarily pursuant to the Convention on Physical Protection of Nuclear Materials. We must have measures appropriate to the strength of the source in question.

S.H. NA (Republic of Korea): The Philippine delegation would like to raise the issue of police reports. It should be emphasized that the function of the police is very important at the initial stage.

L.A. BOLSHOV (Russian Federation): I have a question to the whole panel. Several presentations have been made on emergency response to a radiological threat in different countries. I want to put a case to you. Say, in your country, somebody took a smoke detector from an airplane and made, with strong support from the media, a very loud public announcement that radioactive material had been dispersed in the centre of your beautiful capital, and this information spread through the national TV channels, and the emergency response system should do its job. My question to the panel: How would you respond? To the real situation or to what is announced in the media?

S.H. NA (Republic of Korea): Before asking our panel, I'll remark that this is the point I raised concerning the initial stage of emergency response. Most countries would like to invite the police or whichever organizations can react immediately to mitigate the problem. Now our panel will answer.

I. OTHMAN (Syrian Arab Republic): We have to respond to the real situation. You cannot mobilize everything in the country just to respond to media exaggeration. In fact, an emergency planning rule is to estimate the extent of the problem in the beginning and to deal with the real situation, not with what you hear from others.

W. WEISS (Germany): I agree with what has been said. We have to respond, there is no question about that. We have to tell the population what we know about the incident but we also have to acknowledge that there are different levels of response. Not every event is an emergency, and organizations exist to deal with that. They could identify the problem, classify it, assess it and then communicate it without declaring an emergency. If it turned out that people were at risk, then this would be an emergency situation and would be dealt with as such. I mean, we must assess the situation and communicate this to the population, but not everything that is reported, be it real or fictitious, must be an emergency.

I. USLU (Turkey): The IAEA, as I mentioned in my presentation, is preparing a TECDOC on preparedness for nuclear and radiological emergencies that contains a chapter on credible and non-credible threats from terrorists.

M. CRICK (IAEA): I think this is picking up on Ms. Nilsson's point about pre-emergency assessment. Of course, there are organizations in countries in place for that sort of assessment in general. They will be looking at whether the information is credible from a logistic point of view, whether the event makes sense from actual facts represented, but they are also looking at psychological profiling and such issues. Also, there is a need for a technical contribution from the radiation science community to help establish the credibility of a threat prior to an actual event, i.e. to have some integration of assessment before any decision is taken to activate response.

G.P. SRIVASTAVA (India): My question is an extension of Ms. Nilsson's question and is addressed to all panel members. Yes, you did mention that we may not find immediate solutions for the actions here in this conference. Nevertheless, everybody here would like to find out where we are today and where we should go. Is it pertinent, or is it advisable in the view of the panel, to follow the practices recommended by the physical protection system described in INFCIRC/225(Rev. 4) for the credible radiological sources that we are talking about here, and also to follow emergency preparedness on the same lines? Internationally, we have an infrastructure available for international courses being organized by the IAEA and some of its Member States. In my opinion, we have some international consistency to the level of a benchmark which we can follow till we correctly decide on the full code of conduct practices relevant to this subject. So does the panel feel that, till that time, Member States could continue along these lines?

M.T. ESTEVAN (Spain): As Mr. Vinhas was saying, I would like to point out that every case is different. Within a general international standard or law, every country needs to study its own possibilities, needs, dimensions, emergencies and plans for physical protection. To talk of the USA, Brazil or China, given their size and population, is not at all the same thing as talking about Denmark, Spain or Bolivia, and consequently I think that, given an international basis, each country has to develop its own response because each case is unique. Lack of response is what we must avoid. We must not be in the situation where we have to improvise. We must know how we are going to communicate with our security forces. Whenever a source is lost or stolen, we have to know where it comes from, who the owner was and who is ultimately responsible. In other words, we have to have an inventory of all our sources. No industrial sector in the world keeps a proper inventory, but if they did, they would be able to keep track of what was going on. In reality, it is not as difficult as it might seem.

K. HIROSE (Japan): When orphan sources are discovered or malevolent uses of radioactive sources occur, we need a professional organization that is expected and prepared to take over those sources. I'd like to hear a comment from the panel.

S.H. NA (Republic of Korea): If you allow me, that is not the main subject of this discussion.

A.M. BACIU (Romania): I'm the Head of the NBC Counter-terrorist Unit. From our point of view, the response has two aspects: reactive and proactive response. We have a special unit of the national regulatory body which is responsible for all the aspects concerning proactive and reactive response. Sometimes we have a false alarm and sometimes a real alarm. And as my predecessor said, we have to identify the isotope, the radionuclide and the activity. With regard to these three aspects, we are prepared to make a professional response. Otherwise, we are swimming in murky waters. For a proactive response we need to have good co-operation with intelligence services because without information, we cannot find orphan sources. And for intelligence, we need to use all existing measures and activities with a legal basis, and to take advantage of international co-operation to find orphan sources.

I. OTHMAN (Syrian Arab Republic): In fact, without these three elements, we cannot do anything. I agree that we have to identify the situation before taking any action. Information is very important, because without it, your detector will not find the source.

E. GIL LÓPEZ (Spain): I'm from the Spanish National Safety Council. Throughout this conference, we've been analysing mechanisms for protecting sources, for combating illicit trafficking and for stepping up emergency preparedness. Common to all the accidents and incidents we've been discussing is the loss of control of the sources. So, to the authorities and organizations that have sponsored this conference, I would venture to suggest that some kind of working group should be set up which could set down criteria and rules or guidelines for identifying what should be done when there is loss of control and how we can identify circumstances which might precede that loss of control. I think that this would be useful because it would add value to prevention systems as well as to response systems in dealing with radiological emergencies. Moreover, we should bear in mind that we have organizations and authorities, such as the International Criminal Police Organization (ICPO-Interpol), that are specialized in radiological matters and in research and investigation. They should pool their efforts in order to provide mechanisms to devise criteria and guidelines to deal with situations in which loss of control occurs.

S.H. NA (Republic of Korea): Good point. I think that we will take the comment and the suggestions.

A. STAVROV (Belarus): I represent the International Environmental University in Belarus. I have a very brief comment and also a question to the panel as a whole. As was already stated here, the prevention measures for emergency situations involving radioactive sources depend to a great extent on public reactions. Experience in my country has shown — and my country suffered greatly after the Chernobyl accident —that the implementation of a State programme on 'radiological education' simplified the dialogue between the people in charge and those who need to make decisions on how to prevent or mitigate the consequences of an accident. I think the experience we have accumulated, and similar experience in Ukraine and the Russian Federation, could be taken on board in other countries as well, not directly, because I hope that similar accidents will not happen in future. Nonetheless, the experience exists and it could be useful. Now, to my question: some time ago, with the participation of the IAEA, we developed and implemented an ITRAP programme on establishing minimum requirements for equipment and technology to be used to prevent illicit transboundary movement of nuclear material. As many statements made here have shown, I think that a similar kind of programme should be developed in order to search for, find and recover orphan sources. Furthermore, in a number of cases, it was obvious that the consequences of improper handling of sources were significant because there was no technology at hand to detect such sources. I would like to hear from the IAEA whether or not something similar to ITRAP is being planned in order to search for, track and recover orphan sources.

S.H. NA (Republic of Korea): Thank you very much for the comment and the questions, which have already been dealt with in Panel Discussion 1.

J. BALLA (Hungary): I'm an engineer and the former Head of the Radiation Techniques and Technology Department of the Institute of Isotopes Co. Ltd. Let me start by comparing the topic of this meeting with the terrorist attack against the World Trade Center. We are speaking right now about the airplane but not about the pilot. We see the topic of the meeting — radioactive sources — but not the engineers and operators. I think that if we look at the problem from the engineering viewpoint, the best terrorists would be the engineers and operators who deal with the sources daily. Also, we're speaking about sources, but not about equipment. A source rarely exists alone; normally it is inside some piece of equipment or device, and to solve the problem when we have the source itself, we also have to manage the equipment during decommissioning. I have seen many devices in developing countries where there was not enough knowledge to do anything with them. So it is not enough to create a database on sources; we need a database about the equipment as well. I am aware of the conflict involved, i.e. if we have a database on equipment, terrorists will also gain more knowledge. But somehow, for effective and safe decommissioning of discovered orphan sources, we have to have more knowledge about the related equipment. If we look back over the last 10–15 years, we see that the recommended working life of high activity sources has increased, practically doubled, to 20 years or more, so there is a possibility that when a source is stored for longer than the recommended working life at the facilities of the former users, there is no longer proper technical knowledge to decommission it.

S.H. NA (Republic of Korea): Thank you very much for pointing out the lack of information in an area that we need to consider. However, I don't think that this subject is part of the panel discussion. To summarize this panel discussion: we need to investigate certain areas more thoroughly and to establish benchmarking projects. We need to adopt your findings and suggestions and to seek co-operation through the international organizations. The IAEA could take those things into account through projects and research. We have discussed emergency response and preparation of emergency systems and have understood that we have very limited capabilities. However, we have been using those mechanisms for nuclear facilities. Now we recognize a new area for the malevolent use of radioactive material. We expect, sooner or later, to understand these areas, and to disseminate this information to all participants.

SUMMARY OF PANEL DISCUSSION 3

The session was opened by its chairperson, S.H. Na, of the Korea Institute of Nuclear Safety, who started by explaining that Mr. Eun, who was to have chaired the session, could not be present because of intense media reporting of the loss and subsequent recovery of a 15 mCi[1] ^{137}Cs source. It was a clear example of the way that an event not significant radiologically can have major repercussions in the media and the eyes of the public.

Mr. Na proffered to the audience some of the key issues related to preparedness for radiological emergencies arising from the malevolent use of sources. He reflected on the need to strengthen existing systems to address the new scenarios of RDDs, deliberate contamination of food or water, and threats by terrorists to use radioactive material. This would involve reviewing and enhancing systems for ensuring co-ordinated command and control, training first responders, medical response, rapid and practical technical assessment, law enforcement, use of intelligence and threat assessment, and public information, as well as international co-operation.

The session comprised six presentations: Mr. Vinhas reviewed the Goiânia accident of 1987 in Brazil and Ms. Estevan reviewed the Acerinox incident in Spain in 1998, drawing lessons that may apply for planning response to the new scenarios. Mr. Weiss gave a technical analysis of the possible consequences of an RDD, concluding that the actual radiological consequences would be far less than the consequences perceived by the public, and that effort was needed to plan effective public communications. Mr. Uslu presented the functions that would need to be performed in response to radiological emergencies, and Mr. Othman discussed the administrative and technical infrastructure needed to prepare for such responses. Mr. Ugletveit discussed the elements of international co-operation in sharing information and resources to mitigate the consequences of such a radiological emergency. The presentations were followed by questions and comments from the conference participants.

A number of underlying themes were identified in this session:

(a) The importance of preparedness, realized through developing co-ordinated arrangements for response, assigning clear authorities and responsibilities, making available adequate human and financial resources to establish and maintain the necessary arrangements,

[1] 1 Ci = 37 GBq.

establishing response criteria in advance, and training and exercising relevant personnel. IAEA publications, especially Safety Standards Series No. GS-R-2, can help provide benchmarks for this process. However, they need to be reviewed and expanded to reflect best practice and lessons learned from real events and exercises for response to the new scenarios.

(b) The need to ensure that arrangements are in place to address the principal new scenarios of malevolent use of radioactive sources, including arrangements for proactive as well as reactive response (i.e. urgent action to assess the situation and alert the authorities following a threat but prior to an attack, as well as managing the response actions after an attack). This will include reviewing systems of command and control, first response, medical response, intelligence and law enforcement actions, technical assessment and radiation protection provision, and delivery of accurate, timely and consistent public information.

(c) The benefits of international co-operation in this planning process, including the sharing of relevant information and resources.

The following conclusions may be drawn from this session:

(1) Taking account of the need to respond both proactively and reactively to the new scenarios presented by the possibility of malevolent use of high risk radioactive sources, all States (including both IAEA Member States and non-Member States), as well as the IAEA, need to make concerted efforts to enhance the current national and international response arrangements.

(2) States need to strengthen their mechanisms for providing international assistance within the framework of the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency.

(3) Communications arrangements between States and the IAEA's Emergency Response Centre need to be enhanced with regard to sharing information and co-ordinating the rapid and effective provision of assistance.

(4) IAEA Member States, States Parties to the Assistance Convention and the IAEA Secretariat need to clarify the roles they would have to play in the event of such a radiological emergency or threat thereof.

ROLE OF THE MEDIA PUBLIC EDUCATION, COMMUNICATION AND OUTREACH

(Panel Discussion 4)

Chairpersons

H. Boutaleb
Morocco

M. Gwozdecky
IAEA

ROLE OF THE MEDIA, PUBLIC EDUCATION, COMMUNICATION AND OUTREACH

H. BOUTALEB
Université Mohammed V Agdal,
Rabat, Morocco
E-mail: presidence@um5a.ac.ma

I am very happy to be chairing Panel 4 on the "role of the media, public education, communication and outreach". I should like to thank the organizers and congratulate them on the success of this important conference, which has enabled us to have a fruitful exchange. I hope that this session will contribute to our deliberations and lead to proposals for pathways of productive interaction between the authorities responsible for the safety and security of radiation sources, the media, the non-governmental organizations (NGOs) and the public.

Allow me to present you with some proposals for your kind consideration.

As you know, in 1996 the IAEA published the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources (commonly known as the BSS). These Standards represent international consensus in the field of radiation safety and are based on the presumption that a national infrastructure is in place. Moreover, they underline the fact that the essential parts of a national infrastructure are: legislation and regulations, a regulatory authority, sufficient resources and adequate numbers of trained personnel. They stress lastly the role of the national infrastructure in setting up appropriate means of informing the public, its representatives and the media about the health, safety and security aspects of activities involving exposure to radiation and about regulatory processes.

Similarly, the 2000 Buenos Aires Conference of National Regulatory Authorities with Competence in the Safety of Radiation Sources and the Security of Radioactive Materials concluded that knowledge is the initial essential component in achieving the safety and security of radioactive sources, and education and training are the most important pathways leading to their achievement. It also concluded that there was a need to educate and train the public.

The requirements of the Standards stipulate:

(1) That a national infrastructure be in place. A number of developing countries have no national infrastructure or, when they do exist, they are

ineffective. Of these States, some fifty are members of the UN but not of the IAEA. And as Mr. González has put it so well, a global danger requires a global response. For today, no State is safe from the risks of the malevolent use of radioactive sources. As several speakers have pointed out, the role of the IAEA in this regard is to implement a worldwide model project covering all the essential elements of a national infrastructure.

(2) The essential elements of a national infrastructure include the availability of sufficient resources and qualified personnel. An international aid programme should be set up in the developing countries to address equipment shortages and the additional expenditure resulting from the application of appropriate security measures. Also, training of a sufficient number of qualified staff is a fundamental task if the model is to succeed. The role of universities and training centres is very important in this regard.

(3) If it is dangerous, or at the very least ineffective, for States to keep the public informed only during periods of crisis or of nuclear terrorist threat, then it would be highly advisable to develop an efficient and long term information and training policy to win the public's confidence. In this context, we can make a number of suggestions:
   (a) That the authorities organize access to information using information and communications technologies (CDs, the Internet, films, etc.) for the use of the public, the NGOs and the media;
   (b) That the IAEA develop standard programmes for the use of target groups and train the trainers in how to use these programmes;
   (c) That permanent contact units be set up between the authorities and the media in order to better inform the journalists and to provide them with the information they need to carry out their missions;
   (d) That training sessions be organized for the interested public, the NGOs, the media, etc.

(4) It is clear that the role of the media in public information is very important. The need to provide accurate information without being alarmist should be the aim of all authorities and the media. The role of the media in the developing countries is especially important in view of the high level of illiteracy amongst their populations. An illiterate population is far more vulnerable to fear and panic in an emergency.

In conclusion, we can confirm that the roles of the IAEA, the authorities, the media and the NGOs are important for building public confidence in the nuclear industry, based on the development of a scientific culture which presents a balanced view of its benefits and its risks. This is the best element of defence in depth for the public and for preparing the public to react better in times of crisis or in the event of a malevolent use of radioactive sources. However, we can also affirm that training is crucial to the success of this strategy. Not only training of qualified personnel, but also training in this field for leaders and trainers, NGOs and the media.

SCIENTIFIC AND TECHNICAL ASPECTS OF THE MITIGATION OF POSSIBLE CONSEQUENCES OF THE USE OF A RADIOACTIVE SOURCE IN A TERRORIST ATTACK

L.A. BOLSHOV, R.V. ARUTYUNYAN, O.A. PAVLOVSKIY
Nuclear Safety Institute,
Russian Academy of Sciences,
Moscow, Russian Federation
E-mail: bolshov@ibrae.ac.ru

The key factors which determine the potential threat of ionizing radiation sources (IRSs) in terrorist attacks are the abundance of such sources in various fields (industry, agriculture, medicine, independent power sources) and the problems of registering, licensing, regulating, monitoring and preventing the illegal transport of these sources. These problems are not completely solved, especially in non-nuclear industries. The relative simplicity of production of ‘dirty bombs’ and of the means and methods of their transport are also contributing factors. A large number of ‘orphan sources’ are constantly being found (38 cases in 1997–2001) and there is a high level of IRS theft (50 cases in the same five years); these figures confirm the real difficulties in organizing the registering and monitoring of radiation sources. The situation in other industrially developed countries is nearly the same. In the United States of America, for example, up to 200 radioactive sources are lost annually.

Existing response systems developed and effectively functioning for radiation accidents and incidents are not suitable as an adequate response to radiological terrorist attacks or to simulated radiological threats. Existing methods and computer codes, for example, which describe the behaviour of radioactive substances in open terrain fairly well, do not function effectively in urban conditions. Therefore three dimensional methods of aerodynamic modelling must be used to obtain realistic assessments and develop adequate models of contaminant admixture distribution in urban conditions, and to detect areas with typical stagnant zones and territories with anomalously high contamination levels. Examples of calculations using one such model (currently under development at the Nuclear Safety Institute of the Russian Academy of Sciences (IBRAE)) are given in Figs 1 and 2. Analysis of the results of such calculations conducted for specific areas of urban territory and various scenarios of terrorist attacks using radioactive substances can be used in future

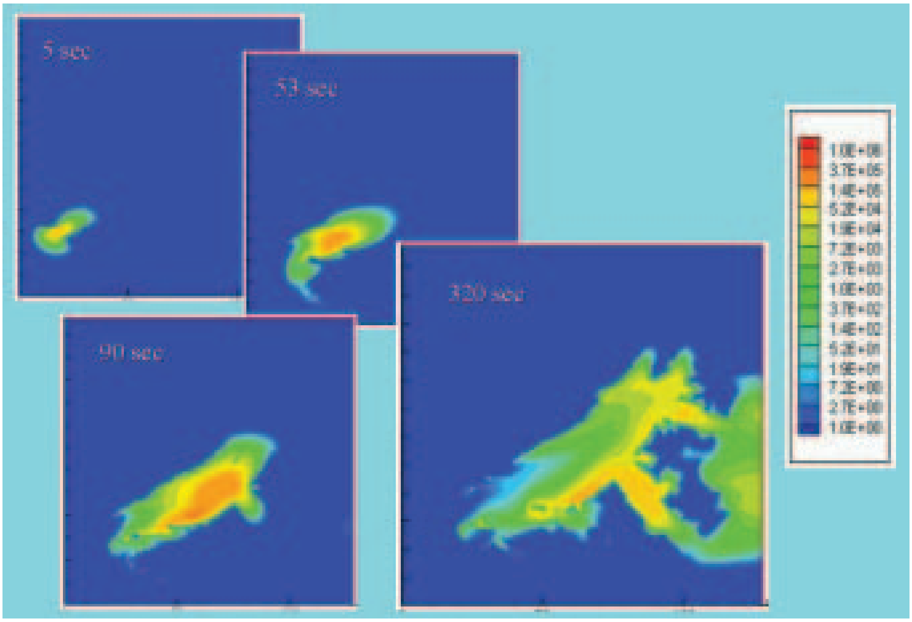

FIG. 1. Dynamics of change of ^{241}Am concentration in air for the case of a bomb with a radioactive source, for urban conditions (relative units).

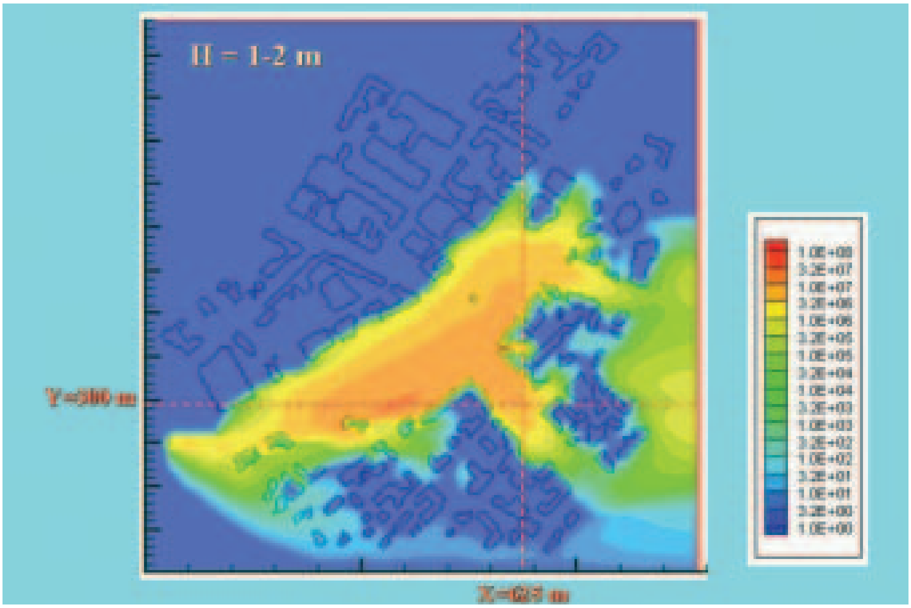

FIG. 2. Integral of ^{241}Am concentration in air for the case of a bomb with a radioactive source, for urban conditions (relative units).

for upgrading the system of measures for collective protection of the population, especially with respect to sheltering of the population and evacuation to uncontaminated regions.

When examining the problem of the possibility of radiological terrorist acts, one should take into account the need to consider the many means of dispersion in the environment of radioactive substances that cause harm to people's health and the environment, and cause social and economic damage.

Recently the attention of the media, specialists and the public has been attracted by dirty bombs. It is important to note that the radioactive filling of a dirty bomb may be as little as fractions of a gram (see Table I), and conversion of ordinary explosives into a dirty bomb does not require any complex technical solutions.

This, together with the low weight of such devices, simple means and methods of transportation to a target, difficulties in detection, and the possibility of simulating acts of radiological terrorism, makes this problem topical in terms of the attraction to terrorists of dirty bombs as a means of radiological blackmail. The relative difficulty of detecting some β and α emitters (Sr, Pu isotopes and others), combined with the anxious attitude of society towards the real or imaginary threat, may lead to very serious consequences even in the case of a false threat to carry out a radiological terrorist attack.

Examining the problem as a whole, it may be stated that a terrorist attack involving the use of radioactive substances can lead to the following negative consequences in society:

(a) Direct damage from the terrorist attack connected with possible loss of life and health, destruction of or damage to the public infrastructure and loss of property;

TABLE I. QUANTITY OF RADIOACTIVE SUBSTANCE (g) IN A DIRTY BOMB WHICH MAY REQUIRE POPULATION PROTECTION MEASURES TO BE TAKEN AT A DISTANCE OF 100 m OR MORE FROM THE POINT OF EXPLOSION

Weather category[a]	Co-60	Sr-90	Cs-137	Ra-226	Pu-239
A	0.020	0.11	1.0	2.6	0.82
D	0.052	0.28	2.8	6.9	2.6
F	0.021	0.11	1.0	2.8	0.88

[a] A: strong instability; D: neutral conditions; F: stable conditions.

(b) Losses due to mitigation of the consequences of the terrorist attack, increase in the required level of radiation monitoring, population protection measures and rehabilitation of the contaminated territories;
(c) Worsening of the social and psychological situation both in the contaminated territories and in areas without noticeable changes in the radiological situation;
(d) Indirect damage connected with losses due to withdrawal of some territories from normal operation, possible closure of agricultural and industrial facilities, loss of customer demand for goods produced on the territory of the terrorist attack;
(e) Implicit losses due to strengthening of society's negative attitude towards radiation and the nuclear industry.

Assessments of economic losses in the mitigation of the consequences of the Chernobyl accident in various regions of the Russian Federation can be given as an example (Table II). The table shows that these losses can be very high (US $100 000–900 000 per man·Sv of the collective dose of population exposure) and secondly, it shows the rapid increase in cost per man·Sv with a decrease in initial received collective dose (for example, compare the Bryansk and Tambov regions).

The international community is facing the problem of effective counteraction of radiological terrorism due to the threat of such attacks.

TABLE II. COMPARISON OF ABSOLUTE AND NORMALIZED (TO 1 man·Sv) LOSSES CONNECTED WITH THE MITIGATION OF THE CONSEQUENCES OF THE CHERNOBYL ACCIDENT

Region	Zone type[a]	Collective dose (man·Sv)	Payments up to 1993 (10^6 US $)	Payments per unit dose (10^3 US $ per man·Sv)
Bryansk	1, 2, 3	305.5	42.4	140
Tula	1, 2	131.0	42.7	330
Oryol	1, 2	24.1	12.6	520
Kaluga	1, 2	18.2	7.6	420
Voronezh	1	3.8	1.6	420
Tambov	1	0.8	0.7	875

[a] Zone types: 1 — privileged socioeconomic status (1–5 Ci/km^2 (1 Ci = 37 GBq)); 2 — zone with the right to remove; 3 — zone of resettlement.

Another task — construction of a response system which can mitigate the consequences of the use of radioactive substances by terrorists — is also important. Experience from past accidents and incidents shows that errors in response systems lead to heavy consequences for society. The indirect consequences of inadequate management of the radiation risk tend to be on a greater scale than the direct losses.

Radiophobia makes society vulnerable to the threat of radiological terrorism. Combined with the wide availability of devices for the detection of minor increases in radiation background, such a fear makes the whole system significantly unstable. A minor threat of a terrorist attack using radiation sources activates mechanisms leading to an increase in social risk. In this case the value of the indirect damage due to a disproportionate reaction on the part of the population, caused by fear, will inevitably exceed all the consequences of the radiation exposure itself. The fear epidemic can travel especially fast in densely populated areas with developed communications, threatening the whole system of public infrastructure.

The current mistaken attitude of society around the world towards the real consequences of past radiation accidents, and, as a result, to possible consequences of radiological terrorist attacks (direct and indirect danger to health and the environment, social and economic losses) has a historical background (the nuclear arms race, dramatic consequences of nuclear bombing of Hiroshima and Nagasaki, accident at Chernobyl). It also appeared as a result of incorrect information amongst nearly all social, public and professional groups about the real levels of radiation risk from the normal operation of the nuclear fuel cycle (Fig. 3).

Thus active work with the public, media representatives and leaders at various levels is required to explain the real risks connected with the potential use of hazardous radioactive substances by terrorists. Consolidation of the efforts of specialists in various countries in this endeavour is absolutely necessary.

There is an urgent need for working on upgrading the legal and normative basis at all stages of the IRS life cycle, and for dealing with violations of these laws and regulations. It is important to note that direct transfer of the normative basis developed and effectively used for the purposes of radiation protection of the population and personnel to situations connected with the potential contamination of local territory in the case of radiological terrorism is incorrect. The situation requires the development of additional criteria for the establishment of adequate standards.

Populism, which prevailed in the Russian Federation in the post-Chernobyl period, led to the legal introduction of strict sanitary standards which could not be afforded even by more developed countries. The basic

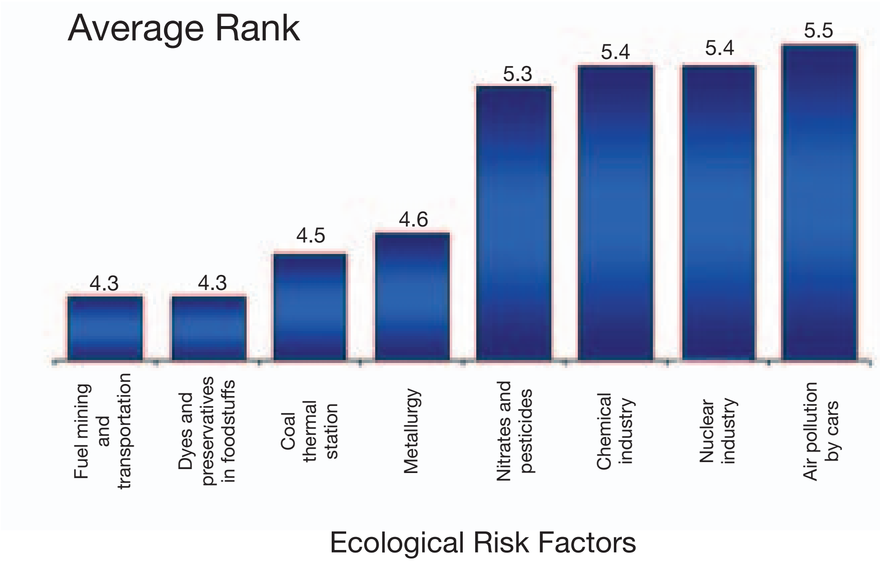

FIG. 3. Comparison of public attitudes towards various risk factors according to polls of 560 top risk managers in 87 regions of the Russian Federation in 2000.

concepts of the Russian Federation law concerning protection of the environment can be taken as an example. This document defines the terms ‘emergency ecological situation’ and ‘ecological disaster’ as:

— Emergency ecological situation — situation with stable negative changes in the environment threatening the health of the population;
— Ecological disaster — deep, irreversible changes in the environment leading to a substantial worsening of the health of the population and violation of the natural balance.

The values given in Table III are to be used as criteria of radiological safety. The use of such criteria leads to a situation where a minor violation of standards, which does not influence health and which would be acceptable in most countries of the West, is a source of serious anxiety to Russian society. The Chernobyl legislation also contributes to this, as it guarantees compensation for health losses for the residents of the Chernobyl area, while their level of exposure is certainly less than the level of fluctuations of the natural background. At the same time, from the point of view of scientists, such dose levels are considered absolutely safe for human health.

Thus the IAEA initiative for the development of a system of categorization of IRSs on the basis of the potential ability of various sources to

TABLE III. DOSE LIMITS FOR DEFINING THE RADIOLOGICAL SITUATION IN A CONTAMINATED REGION OF THE RUSSIAN FEDERATION AS AN ECOLOGICAL DISASTER OR AN EMERGENCY ECOLOGICAL SITUATION

	Ecological disaster (Article 59)	Emergency ecological situation (Article 58)	Relatively satisfactory situation
Effective dose (mSv/a)	>10	5–10	<1
Carcinogenic risk	$>5 \times 10^{-4}$	$(2.5–5) \times 10^{-4}$	$<5 \times 10^{-5}$

lead to deterministic effects on human health should be supported. At the same time, as it appears to us, assessment of the possible long term stochastic effects of radiation on people should be added to the categorization system, together with the possible social and economic consequences of terrorist attacks using radioactive sources. We are fully aware of all the methodological difficulties in these assessments.

The perception of radiation risks is incorrect not only at the level of everyday life. Prejudices connected with radiation can be found in nearly all professional, social and public groups, including representatives of legislative and executive powers responsible for ecological regulation. Work on correcting the attitude of society towards the threat and potential consequences of radiological terrorism requires a different approach for each target group. Information for political and economic decision makers, for example, must include not only data on the levels of radiation risks and measures for population protection, but also data on the economic effectiveness of these measures, their social acceptability and their sufficiency.

It is also necessary to reconsider the nature of the considerable difference in the strictness of the standards used in nuclear and other branches of the national economy. Table IV shows, as an example, the values of carcinogenic risks existing in the Russian Federation at the maximally permissible levels for pollution of water, air and working areas. The table shows that a risk level of over 10^{-3} is associated with 30% of the standardized substances in water, 22% of the air pollution and over 80% of the substances monitored in the working areas of facilities. At the same time, the population exposure risks associated with the radiation standards are only 5×10^{-5}, and 10^{-3} for personnel, but in real life the risks tend to be substantially lower.

TABLE IV. CARCINOGENIC RISKS FOR STANDARDIZED CHEMICAL SUBSTANCES AND THEIR COMPOUNDS
(from NOVIKOV, S.M., PORFIRIEV, B.N., PONOMAREVA, O.V., IBRAE report, Moscow (2000))

Risk	Water in ponds		Atmospheric air		Working area	
	Absolute	%	Absolute	%	Absolute	%
$>10^{-2}$	7	8.0	2	5.4	42	45.1
10^{-2}–10^{-3}	19	21.8	6	16.2	34	36.5
10^{-3}–10^{-4}	29	33.3	13	35.1	10	10.7
10^{-4}–10^{-5}	23	26.4	9	24.3	7	7.5
$<10^{-5}$	9	10.5	7	19.0	0	0
Total	87	100	37	100	93	100

The level of protection of society from the threat of radiological terrorism, together with the size of the losses due to indirect consequences, is to a large extent defined by the nature of the public reaction. Directed work in this field can be considered a preventive measure which does not cost much. But its complexity should not be underestimated. The problems of informing the public on issues connected with radiation risks require not only a professional approach at the interface of many scientific disciplines but also resolution of the specific demands of presenting science-intensive information to a non-professional audience. Consolidation of the efforts of specialists in various countries in this endeavour is absolutely necessary.

To generalize what has been said above, we would like to point out the directions important from our point of view for counteraction and mitigation of the possible consequences of radiological terrorist attacks:

(1) Systems analysis of the practical experience of reacting to radiological accidents and mitigation of their consequences, so that recommendations on effective countermeasures in the event of radiological terrorist attacks can be given;
(2) Development of scientific approaches and means for realistic analysis of possible scenarios and for predicting the scale of consequences of radiological terrorist attacks;
(3) Development of a concept for organization of a system of national and international expert scientific and technical support for response to acts of radiological terrorism;

(4) Analysis of possible causes of incorrect estimation of the indirect (psychological, social, economic) consequences of radiological terrorism by society, and development of recommendations for mitigation of radiophobia;
(5) Analysis of the availability of various radioactive materials, and ranking of these according to the potential threat in the event of their use in terrorist attacks;
(6) Development of recommendations on upgrading the system of registering and monitoring of radioactive materials (IRSs, radioactive waste), especially in non-nuclear industries;
(7) Upgrading of the legal and normative basis regulating all aspects of the use of radiation sources in the national economy.

International co-operation in this field is highly important.

THE MEDIA AND DIRTY BOMBS

C.J. HANLEY
Associated Press,
New York, N.Y.,
United States of America
E-mail: chanley@ap.org

During the recent Jose Padilla 'dirty bomb' scare, an indignant US citizen wrote to his local newspaper in Florida complaining that the news media were giving terrorists a recipe for making dirty bombs. "Unless the media eases up on scaring us", he wrote, "the public won't feel safe even leaving their homes. Or perhaps that is what they want", he said, "us staying inside our homes watching the news on how terrorists can destroy us all." It seems our real motivations have finally been uncovered — we in the media want to scare them so much they won't leave their TV screens.

Since the 11 September 2001 attacks, we have entered one of those periods when the practice of journalism comes under closer scrutiny. We're dealing more frequently with subjects that require judgement calls that relate to life or death issues, to national security and individual security.

Those "recipes for terrorists", as they're often called by our critics, were everywhere in news reports immediately following 11 September 2001, when the media reported that some nuclear power plants might be severely damaged by similar suicide plane crashes, that city water sources might be vulnerable to tampering and that anthrax can be made a much more dispersable and effective weapon by adding antistatic powder, such as silica, to anthrax spores. Don't give them recipes, the media heard time and again.

I recently wrote a series of articles for Associated Press wires about the nuclear and radiological terrorism threat. In the main piece on dirty bombs a number of such judgement calls had to be made. The lead paragraphs, for example, told of an expert describing to me how a wire of ^{192}Ir would have to be cut into tiny pieces to be used in a dirty bomb. Perhaps that was a recipe, but it also was stark and graphic, and I felt it would draw more readers into what I thought was an important article, and I used it.

On the other hand, I did not get specific with a surprising piece of information — about the huge amount of caesium chloride powder that sits in food irradiators manufactured by a company in New Jersey. I wrote that such a manufacturer is just 35 miles from the USA's largest city. I didn't specify the location or name. That, perhaps, was just a fig leaf of precaution. But on another potentially more troubling matter, I chose not to pursue and report the facts at all — that is, the truly massive amounts of caesium that I understand are sitting at the US nuclear complex at Hanford in Washington State. Imaginative minds could reel off some frightening scenarios involving such material. I decided to leave it alone.

I'm not sure how well I could defend each of those decisions, but I'm like any journalist, leaning towards disclosure in the face of critics who lean towards secrecy. Perhaps the foremost duty of the news media is to focus attention on problems in society — in this case on vulnerability to terrorism, to inform citizens about how well or how poorly their leaders have prepared for contingencies — so that society as a whole, that is democratic society, can work on solutions.

A simple and sad example comes to mind: think of how our world might be different today if some whistleblower or leaker two years ago had caused American news organizations to be interested in the fact that questionable young men were taking flying lessons in Florida. Perhaps that exposure would have given some others ideas — recipes — for suicide skyjackings, but the public exposure might have led to solutions.

Another example, if I may, from my own file: last summer I reported, from ex-Soviet Georgia, on the vulnerability of the former Sukhumi nuclear institute, which sits abandoned in the secessionist region of Abkhazia. As is known, as much as two kilograms of high enriched uranium is missing from the institute, and much more — in equipment, design plans, radioisotopes — may also have been at risk in recent years, in the security vacuum that exists there. Writing about Sukhumi's vulnerability might be described by some as an advertisement to proliferators. On the other hand, when I realized that my news organization, with its thousands of media outlets, had never taken note of this serious problem, I felt that there was no question that it needed to be publicized.

The other aspect of the story of dirty bombs and the media relates, of course, to security alerts and ultimately, perhaps, to an actual incident and its handling by the media.

A recent 'orange alert' in the USA was tied to the possibility of a dirty bomb, according to public statements. Even people in rural mid-America were frightened into preparing for some kind of attack. It seems, however, that the alert was based on somewhat shaky information.

If we look back to June 2002 and the alleged dirty bomb plotter Jose Padilla, that also appears to have been an overstated situation. You will remember the suddenly scheduled news conference in Moscow, of all places, by the visiting US Attorney General, to announce an arrest that had been made weeks earlier in Chicago. To commentators, it appeared politically motivated, to counter the negative publicity emanating from a congressional investigation into intelligence and law enforcement failures preceding 11 September 2001.

Whatever the motivations and reality, the Jose Padilla episode showed that the US news media cannot be depended upon to be discrete, to be measured. We are in an era of 24 hour hunger for news, of fierce competition among cable and satellite news channels, a time in which staid old news organizations such as the Associated Press are dragged into a kind of contest to see who can shout loudest to make routine news seem exciting. (My favourite recent example actually came from Vienna, when the Associated Press rushed out a NewsAlert — the most urgent level of headline — to breathlessly report that “IAEA chief says no surprises in upcoming Iraq report”.)

In any event, the Jose Padilla dirty bomb story was not a shining moment for the US media. One tabloid newspaper warned New Yorkers that such a device might kill 10 000 of them instantly. A national newspaper told its readers that a dirty bomb is simple to assemble. On CNN, they actually displayed a photo of a mushroom cloud, the mushroom cloud of a nuclear explosion, while reporting on the dirty bomb threat.

The simple fact is that we must rely on political leadership to act responsibly. In the Jose Padilla case, the alarm over a dirty bomb had no basis in any real planning by Padilla and his cohorts or in any special skills he was known to have. One scholar and critic of the American media, Marvin Kalb, said he didn’t blame the media in the Padilla case. “The government went overboard”, he said, “and the press went along for the ride.”

One of the dangers of going overboard, obviously, is the risk of crying wolf too often, and of numbing the public to real dangers.

The overstatements and public relations spins can take many forms. One example is the recent US Government announcement that every traveller arriving in the USA will be checked for radiation. I suspect a close look behind that story might find less there than meets the eye — a less airtight system than some might infer. The motivation for any exaggeration might be deterrence, to discourage any ill intentioned traveller, but it could also contribute to a false sense of security.

All these concerns pale into relative insignificance when one considers the biggest concern — the role of the media in the event of an actual, serious incident involving a radiological dispersal device, when the wrong word, the wrong tone, could touch off panic in a crowded city.

Leaders of the news media would, first of all, universally advise full and rapid and authoritative disclosure of what is known. If it isn’t coming quickly from the highest levels, then the news will soon deteriorate to what’s being heard on the streets, from police officers and firefighters and other emergency personnel, and from passers-by.

One major problem area, I think, would involve the description — the categorization — of the health risks associated with any radiation event. This, I know, is a difficult area even among specialists, but I think that, if at all possible, some kind of easily understandable benchmark system of grades of risks, in layperson's terms, de-emphasizing the roentgens, rems and curies, would help the media put the story in proper context. When people don't understand the technicalities in a situation like this, many will assume the worst, and it won't take many to start a panicked flight. Remember, too, that we in the media might otherwise hurriedly turn to so called experts who may not be expert at all, that is who may be all-purpose medical commentators with a limited knowledge of health physics.

In connection with this ultimate possibility of a dirty bomb event, I was interested to read about the Oak Ridge National Laboratory's development of its SensorNet system — a network of devices to detect radiological, chemical or biological agents in the air, and weather and wind direction, and to alert first responders within a very few minutes to the likely pattern and severity of the event. My question, naturally, is where the US news media will fit into this notification process. In the end, perhaps the new US Homeland Security Department will want to inaugurate some kind of alert system through media networks such as the Associated Press, similar to the nuclear alerts of the Cold War days.

Journalists are the first to acknowledge their ignorance. That's why we ask questions. You will find ignorance and errors in my copy, I'm sure. I find them in others', even on what would seem the simplest matters. In a story on those airport radiation detectors, for example, the Associated Press reported that they may be set off by cancer patients who have undergone "chemotherapy". I assume we meant radiotherapy. In another Associated Press story, from Honolulu, about concerns that dirty bombs might arrive on container ships, we wrote that there is a proposal to install "X ray machines" to detect radiation in containers. I believe we meant to refer to radiation detectors that are being paired up with X ray devices that already scan containers for suspicious items.

However, our learning curve in the media can be fast. I was surprised to find that the term dirty bomb never appeared on Associated Press news wires before the 11 September 2001 attacks. Now it appears every day, and I think increasingly we're getting the facts right and helping to prepare our audience of millions for this dangerous new world.

PUBLIC COMMUNICATION DURING EVENTS AND THREATS INVOLVING RADIOACTIVE RELEASES

A. JÖRLE
Swedish Nuclear Power Inspectorate (SKI),
Stockholm, Sweden
E-mail: anders.jorle@ski.se

A Swedish banker once said, “When I see a journalist I run — after him…”. He was a man who saw opportunity in public communication, and somehow I have the same feeling when I look at you, my audience, because you are my target for a message.

I will not talk to you about the “sound of silence”, to quote the Simon and Garfunkel song. Rather, my message is about being a successful vocalist in a large choir.

Recently in many countries there has been considerable public interest in matters of worldwide security. There are opportunities with today’s media, but there are also problems — wherever something is going on in the world, people react as if it were happening in their own backyard.

In my work I come across all the public’s concerns about nuclear power and the various sources of radiation. Although accidents are highly unlikely, incidents are rare and releases of radioactivity are far below regulatory limits, and easily monitored compared with other threats of an environmental nature, these worries are a constant theme.

Names such as Chernobyl and Three Mile Island are still very close to the public’s perception of nuclear matters. This is neither the time nor the place to discuss whether this is right or wrong, but it gives us an indication of what can be expected if we face unknown threats and acts of terrorism connected to real or possible releases of radioactivity.

One of the important goals in working with a regulatory authority responsible for acting in emergency situations is the maintenance of public confidence. The countermeasures to be taken in the event of an accident, terrorism or a threat depend on this confidence. The damage caused by radioactive sources used as a weapon could be less severe than the perception of the danger among the public, not only for those persons close to a release but for those distant from the scene of the release.

Public authorities in all countries bear the task of protecting members of the public from all kinds of danger; sometimes this is an easy task, but at other times it is difficult and the authorities are met with distrust.

Emergency preparedness in the event of a radioactive release always raises the question of communication and of channels of communication. Communication is the most important tool in the protection operations of the authorities to save life and protect health.

Crises like the ones we are talking about at this conference demand communication between the authorities responsible for protective actions and the general public. To protect the public both from possible releases of radioactivity and from panic we must rapidly establish credible sources to communicate with the public and other groups of interest.

During my carrier as a journalist, among other things I covered the catastrophe of the Estonia, the ferry that sank in the Baltic Sea in 1994 with the loss of approximately 850 lives. Even though the accident was in the middle of the night and at sea, the news was broadcast on Swedish radio and on wire services before the first rescue helicopters were on the scene. It was not easy for the public authorities to provide fast and relevant sources of information in that environment, and nine years later it is even more difficult.

Trust and confidence cannot be achieved when a crisis is under way; advance planning is necessary and confidence has to be established in advance. The first and most important criterion for success is a general trust in the public authorities in a country. Public authorities must give the media and the public the correct perception of the competence and knowledge present in their organizations. The easiest way to bring this about is to consider the public perception of any action taken by an organization with a public mission.

Confidence can only be built on a genuine wish to be transparent; openness is paramount.

What we ask from others (e.g. governments, licensees or schools) when it comes to transparency and openness, we have also to provide ourselves.

What, though, builds confidence? In short, transparency, but the key to confidence and trust is more than providing information; the public needs to be listened to, and to have questions answered and to have its concerns addressed — public bodies must communicate, not just inform.

If confidence in a public authority is already established, the first and most important element of successful crisis management is present, but that is not sufficient. It cannot be stressed enough that providing sources of early and accurate information is very important, and that speed is of the essence — speed in this context being not hours but perhaps even minutes.

Very little may be known at the beginning of an emergency, but to be silent is not the answer. On the contrary, a message must be sent out, the message being: “We have a responsibility in this situation, we take that responsibility and we are prepared and willing to communicate about it.”

A fast response requires preparation and easily deployable resources: people and facilities for action and communication. Organizations need to be built on the basis of the delegation of responsibility, and staff members at many levels must be entitled to act; this is true both for technical staff and for communicators.

It is necessary that there be individuals focused on the issue of communication: it is impossible to act, for example, as a managing officer of operations while simultaneously communicating with the news media; such a person can adequately make few decisions of any kind. Many people are unaware of and have no experience of the type of pressure that can be brought about by the news media.

In order to achieve the speed necessary, a communicator needs to be well informed and to have a well defined mandate in all situations. Communicators are the interface of an organization with society. They should be involved, be in the management team and have a mandate to act.

It is sometimes proposed that, to get more accurate reporting, especially in the event of an emergency, the news media should be better educated. I am not of this opinion. Except for a few large news organizations, most of the news media don't have available experts on particular subjects, experts who are likely to be needed only occasionally, especially when it comes to an area such as natural science. This may be regrettable, but the situation is not going to change.

On the positive side, however, the news media are normally very supportive at the beginning of an emergency, since they tend to identify themselves with their readers, viewers or listeners, for obvious reasons. This is why there is so much to be gained from public bodies establishing themselves as an early and reliable source of information. Later on they will get the blame, but they will anyway.

A few words on emergency preparation in the Nordic countries. The Nuclear Power Inspectorate and the Radiation Protection Agency in Sweden have established actions to be taken in the event of an emergency. Much is placed on communicating with co-operating authorities and neighbouring countries.

In Sweden and the surrounding countries all national authorities involved in nuclear emergency preparedness have officers on duty who are available 24 hours a day on mobile phones or pagers, and in most cases information officers are also on duty. Emergency response and communication can thus be started immediately. Rumours of accidents in other countries are normally handled at this level, even if international contact has been established.

The authorities responsible for radiation protection in the Nordic countries have established an e-mail and fax network through which information can be exchanged very quickly.

One problem is the co-ordination of messages from the different authorities involved. In Sweden we try to solve this problem by keeping a protected web page, developed by the Radiation Protection Institute, available to the acting authorities, on which are put relevant information, analysis and press releases. It has been very successful, since it can contain a lot of information, available in one location and immediately.

In conclusion, speed, accuracy and co-ordinated messages are the essential elements of successful crisis management. Most importantly, though, in the Nordic countries one major factor is present: the regulatory agencies have the confidence of the public — this is the fundamental factor on which our crisis management is built.

PANEL DISCUSSION 4

ROLE OF THE MEDIA, PUBLIC EDUCATION, COMMUNICATION AND OUTREACH

Chairperson: **H. Boutaleb** (Morocco)

Members: **L. Bolshov** (Russian Federation)
C. Hanley (United States of America)
A. Jörle (Sweden)

M. GWOZDECKY (IAEA): Mr. Jörle mentioned that people are either running after journalists or running away from them. It is certainly my experience that journalists are like the weather. You know the phrase "everybody always complains about the weather, but nobody ever does anything about it". Well, the same goes for journalists to some extent. We all complain about the media and I would like to know your experience from your perspective. What do we, as experts or as government employees, tend to do wrong that gets in the way of your covering a story as we might like to see it covered?

C. HANLEY (USA): I suppose the number one problem might be secrecy. Obviously, in these sensitive areas, there has to be some of that, but perhaps it is overdone. I think particularly in a technical area, without as full an explanation as possible of the background, we tend to make mistakes. Perhaps at times our sources in government and the more technical agencies do not consider our ignorance enough and do not help sufficiently. I think the problems all concern the availability of information, the accessibility of authoritative officials to respond to particular situations and questions, and the provision of a lot of background material. Do not ever be afraid of dumping paper or web sites on journalists, because that is what we thrive on. At times there is an insufficiency of that kind of thing as well, I believe, on the part of certain agencies.

S.V. NOVIKOV (Russian Federation): I would like to put a question to the journalists. Here in this room, representatives of many countries have been discussing the issue of radiological terrorism for several days. Now, after this discussion, will radiological terrorism become more, or less, attractive to a potential terrorist?

C. HANLEY (USA): I think you would have to ask that question of a terrorist rather than a journalist, but your opinion is as good as mine. I haven't heard anything dangerous discussed here that would not be available or deducible by anyone really intent on doing something. As for the headlines that refer every day to dirty bombs, I think that horse is out of the stable already. The flood of such information after September 11th was pretty phenomenal and, as I said, the Associated Press wire, which carries an enormous volume of material every day around the world, never even used the term dirty bomb until November 2001. Interestingly, this was not something we journalists cooked up; this was actually in a report or press release from the very Agency that is hosting us here today. I think that the flow of information is necessary. The demonstration of interest and enterprise on the part of all of your agencies in trying to face this problem has to be very reassuring to the public. Whether, along the way, a terrorist is going to get an idea or not, I am afraid, is an imponderable that comes with the territory.

B. DODD (IAEA): We have, as we have been discussing this week, developed a categorization of radioactive sources: categories 1–5. Part of the purpose of this was public communication. The question is to Mr. Hanley: Do you believe such a categorization with a plain language description of what each category means meets your criteria for communication? For example, categories 1–3 are what we describe as dangerous sources in the sense that they can cause death or permanent injury in a short time. Do you think that is a good idea and suitable? Can you use it? And if so, how can we best get this categorization and its plain language description out to the media for their use?

C. HANLEY (USA): That is a very good question and I think that I am familiar with the categorization, which strikes me as a very good basis for starting on this problem of public perception. As for getting it out, obviously national nuclear agencies would be the primary source to the media around the world, and the IAEA would have to work on that. As was discussed earlier, there seems to be quite a programme planned for dealing with this issue. I first saw the categorization a year ago and I was quite impressed. The examples were easy to understand and I think that goes a good way towards helping the media to make it more comprehensible to the general public.

M. ARAMRATTANA (Thailand): I have some comments and questions. First of all, today's modern communication media around the world have access to the same information. But on the technological side of reporting, Western media are often the most efficient. Media in developing countries rely on the Western media's reporting for information on some technological events and accidents, in particular on radiological and nuclear accidents. In developing countries, we are faced with a varying quality of local media reporting what Western media propagate to them. I have experienced two events that demonstrate distortion through translation. One example was a report on studies of Chernobyl casualties translated from the English media. I read the Thai and the English versions, which conveyed different messages. One distinctive difference was that the original reporting did not mention any figure for the casualties of Chernobyl. But in Thai, the media said the estimate was 20 000. Media in developing countries tend to invent facts to make exciting news. Another such incident occurred two years ago, when there was a radiological accident in Thailand resulting in three deaths. The first man who died was about to be cremated. For some reason, the media said that the cremation would disperse radioactive contamination, and that he should not be cremated. People panicked, and the villagers around the temple which was to cremate the body protested, and asked to have the body cremated elsewhere, not in their community. Finally, the victims were compensated, and the local media reported that the body was cremated because his family had received compensation from the Government. The public did not know whether the body was cremated in spite of possible radiological contamination or simply because of the compensation. This demonstrates the distortion that we are facing. My organization has often tried to organize a press conference to communicate facts and figures that should be available. Now to my question following this comment: Is there any programme in the media community to harmonize or to improve the quality of the media in developing countries so that at least the attitude, the understanding of science, can be brought up to par?

C. HANLEY (USA): You raise some very good points, and as with any endeavour, quality is always our first concern. Whether you are in a developed country or a developing country, inevitably the quality deteriorates with lack of resources available, and also depends on the level of education. But to answer your question, there are many programmes directed towards what we commonly call Third World journalists in the USA, to bring them in for familiarization with US media techniques and, I suspect, even specifically for science journalism, or more technical kinds of journalism. I could find out and inform you about what might be available in that area in particular. This has been a growing area of interest on the part of the US media, particularly because of the changeover in the former Soviet Union and eastern Europe. There has been quite a flood of programmes, both taking place in those countries and bringing journalists to the USA for training in US media methods, which, we hope, are worth emulating in many respects. Some of these programmes are Government sponsored, some are sponsored by media corporations and some are sponsored by others — universities and source foundations have been very active in this area.

L. BOLSHOV (Russian Federation): Just a very brief comment on the quality of information, starting from the point of the Thai comment about 20 000 victims of Chernobyl. I want to give you an example of how the media usually presented these numbers. In a more or less general, objective article, you may read that, of all the people involved in the mitigation of the Chernobyl accident, ten years after the accident, 10 000 people had died. At the same time, from an equal number of people not affected by the Chernobyl accident, 10 000 or even more people died in the same period. This is one message. If you do not have enough space in your newspaper or enough broadcasting time, you can cut this information, saying that ten years after Chernobyl, from the cohort participating in mitigation, 10 000 people had died. Or you can have a third version of the same message. Ten years after the Chernobyl accident, from the cohort participating in mitigation, 10 000 people died because of the accident. You can judge the quality of the information for yourselves.

M. GWOZDECKY (IAEA): I want to add one point to the last question. It is not always a matter of the media requiring training, although I recognize that as an issue; it is also a question for those of us on the other side of the fence to recognize that we, too, need to work on the way that we deal with the media. We are undertaking training pretty much on a continual basis at the IAEA, and progressive organizations that deal in communications do this as a matter of course. As an anecdote, I will just point out that two weeks before former US President Ronald Reagan ended his second term in office in the White House — and we all remember President Reagan as being one of the finest communicators — he took media training at this late stage in his career. So I want to suggest that both sides of the equation do need to work on how they get their messages across.

V. KOSENKO (Ukraine): I would like to tell you about the work we carry out in Ukraine and ask our reporter colleagues to assess to what extent we are on the right track. The way we work with the mass media in Ukraine has shown that most reporters have insufficient training. Because they are not sufficiently trained, they distort the situation. For example, one milliröntgen is very often reported as a megaröntgen, i.e. one million röntgen. We are trying to provide the mass media with some basic, simple notions about the subject matter, at least initially. We are trying to make sure that we do not use professional terminology, but rather provide them with the basics to begin with. In order to gain their trust, we also try to provide them with information. We also try to inform the public about how to behave, what to do in the hours and days that follow an emergency. And we try to establish a sequence of information that will be provided, what sources of information exist and how reliable they are. Now, this is what we do. Could you please tell us whether or not we are doing the right thing.

A. JÖRLE (Sweden): I think that you are on the right track because it’s the job of the authorities to translate and to understand the language of your findings and your decisions and you can never leave that to the media. So it seems to me that you are doing the right job.

M. KEREN (Israel): I think my question is for Mr. Jörle from Sweden. Regarding the advice to use communicators, and the comment that accident managers, as radiation professionals, cannot be communicators at the same time, I think that many of you remember Dr. Rosengard, who was the manager of the Goiânia accident, describing, at the end of the conference held in 1997 in Goiânia, how he spent time every day on interviews with journalists. He never rejected any request from the public to come to them and explain the situation, even two weeks or three weeks after the accident. I feel that the best way to promote confidence between the public and the manager of the accident is to have direct contact rather than use professional mediators.

A. JÖRLE (Sweden): Yes, I see no contradiction here, because I am very much focused on the issue of establishing a fast source, but when we are talking about many days and weeks, the expert has to be able to communicate. Also, it is important to know that the communicator doesn't necessarily have to be a former journalist, but simply a person who is designated and able to perform the job.

C. HANLEY (USA): I would endorse that statement. You can see it with airplane accidents, for example. When the airline president gets out there and explains what happened, it instils more confidence in the listeners of getting a straight story. Of course, when you have a mediator, so to speak, you risk error in transmission that harms your credibility long term, so journalists obviously would prefer to get it straight from the horse's mouth.

A.A. MIRANDA CUADROS (Bolivia): This is a good opportunity where we have journalists on the other side for once. So, I want to ask about the systems for discriminating between different kinds of news. In various papers we've heard radiophobia mentioned. Now, what system exists to help us to discriminate between the veracity and reliability of a piece of news and the rapidity with which the news is conveyed and the impact that it can have? How can we distinguish between those different aspects?

C. HANLEY (USA): You've got right to the heart of the matter. Earlier today, Mr. Bolshov asked about the ad hoc situation of plutonium contamination in the city, which the media then sensationalized. It's a related question and I would simply like to discuss that very quickly. I think you have to realize that the media deal with this sort of thing on a daily basis. We get bomb threats and all sorts of threats by phone routinely and I think that we feel our greatest social responsibility in such a situation. It's one thing to report about what celebrities are doing; it's quite another thing when you have the responsibility for either frightening or not frightening the public. I think every professional journalist sits back and thinks very hard about what he or she is doing when dealing with a bomb threat, for example, where the standard handling is simply to report it if you're getting the bomb threat directly, which often happens; at the Associated Press in New York it's a weekly event that somebody will call about a bomb threat. It's conveyed to the proper authorities and then, essentially, we wait and see what happens. If the investigation itself proves to be a very disruptive event, it becomes news and has to be reported; you cannot keep these things secret. In the case of a radiation event (a very rare thing), or a reported or a threatened radiation event, I think the media's response will be more cautious. They will talk to the proper authorities and find the best experts to assess the situation. We all recognize that radioactivity is something that frightens people and that we have to be extremely careful not to report too fast and cause avoidable panic. I think that's the only way I can generalize about a question that really relates to ad hoc circumstances.

F. UGLETVEIT (Norway): We recognize that speed is important in informing the public in the early phase of an emergency. Very often, however, we see that the press is faster than us. There could be several reasons, but I think that the main one is that we use more resources and are more thorough in our quality assurance and verification of the information presented. Is there a way we could alter this or do we always have to be second in that race?

C. HANLEY (USA): In the example of the ferry sinking in the Baltic, which was a terrible story, the media were ahead of the rescue crews, but here we were dealing with a remote sinking ferry out at sea. If you have an event such as a bomb scare in the middle of the city, the event itself can cause such disruption that the media feel an obligation to report something and will do their best to get accurate information from the proper authorities. The first principle of reporting is to go to the right people, the authorized people, to acquire information and not to simply take information from the streets. But if nothing is forthcoming after quite a while from the proper authorities, then it's incumbent upon the media to tell the public something, so that they feel confident about what is going on. However, in the area of RDDs or nuclear threats in general, clearly more work is going to be done fairly soon and I think there'll be more understanding and more co-ordination on the two sides.

L. BOLSHOV (Russian Federation): It's extremely important to be prepared. It doesn't work if you start to look for better solutions after something has happened, and this is true from both ends. Journalists should know whom to call, whom to trust, who is in possession of the most reliable information and, on the other hand, the authorities certainly need some time to check and to verify the information coming to the crisis centre. However, sometimes it is beneficial to release some information, saying that we are not fully aware of what has happened but we are working on the problem. The media should keep the population informed also at this stage of little current knowledge. We have had this experience in dealing with different crisis centres, supporting them through the media. I strongly believe that trust and knowledge should be built at this point.

A. JÖRLE (Sweden): You can always inform the media about the action you are taking and that is also confidence building.

A.K.A.J. BILODEAU (Canada): During the break, I had the opportunity to go into the Internet Café and do a quick search on radioactive sources and it was really interesting to see that I had 280 000 hits. This indicates that there is a lot of information out there on this issue, some probably more valuable than others. In the light of the discussion we had earlier on the issue of perception and co-ordination of messages, my question pertains to the discrepancy between some of the statements issued by the IAEA about this meeting and the way they were characterized by mainstream media, particularly by CNN. On the CNN web site you can read that we are here today to address the imminent threat of terrorist attacks using dirty bombs, while the IAEA statements refer to globally heightened attention to the issue of the security of radioactive sources. I see in those two messages a clear gap and I was wondering if you had any comments.

M. GWOZDECKY (IAEA): Do you want a comment from the one who wrote the one or the one who wrote the other? Why don't I just try to see if I can piece together how that might have happened? I recall the opening session of this conference and I think I heard the word "urgent" used at least three times by each of the principles. I think it would be fair to say that any journalist listening to those presentations might have got the impression that something was imminent. If not an actual attack, at least the word "urgency" does spring to mind and maybe Mr. Hanley can tell us what went through his decision making process as he prepared the stories after that first day.

C. HANLEY (USA): I had nothing to do with the CNN story and I would never write that there was an imminent threat (unless I considered myself a clairvoyant) but the Director General of the IAEA himself said on that first day that measures were urgently needed. There is a conventional point of view that we operate under: that official agencies tend to understate and the media tend to get it right or maybe, at times, overstate. However, obviously we want people to read our stories and to learn and they won't read our stories if they are written in bureaucratese. In other words, if we referred in the lead paragraph to a need for better security measures for radioactive sources, this would not mean a lot to most people, but the issue here is malevolent use of radioactive sources and that needs to be the lead of our stories.

M. GWOZDECKY (IAEA): What we've heard in the last hour and a half can be categorized in two areas: one is a set of challenges for the media — in this pressurized environment, to report responsibly, accurately and with balance on some very complex issues. We have been reminded of those responsibilities very well today. The other category of issues concerns the responsibility of government organizations, experts and industry to be better communicators, to work more quickly at getting out accurate information and to boil down these complex issues more clearly so that they can be consumed by the general public. I hope that we don't walk away from this session feeling that it's only the other side that needs to do a better job. We all understand that both the media and those who are trying to communicate through the media need to work harder.

SUMMARY OF PANEL DISCUSSION 4

In the panel discussion on the role of the media, public education, communication and outreach, it was recognized that the public's understanding of the nature and consequences of radiological emergencies will have a large bearing, perhaps the single largest, on the extent of the consequences of such emergencies. Governments and industry have a critical responsibility to provide the public with accurate and timely information prior to and during such an emergency. To this end, they should develop and implement proactive public awareness programmes to educate the public about the threat and the appropriate response in the event of a radiological emergency, in order to minimize social and economic disruption. The media must recognize their responsibility to strive for balance and accuracy, and accept that there may be some information which should remain out of the public domain for security reasons. For their part, governments must accept the realities of the mass media and be prepared to work proactively with the media to ensure that the public has the information it needs to respond appropriately.

CLOSING SESSION

SUMMARY BY THE PRESIDENT OF THE CONFERENCE

INTRODUCTION

The terrorist attacks of 11 September 2001 triggered international concern about the potential malevolent use of the radioactive sources that are employed for beneficial purposes throughout the world in a variety of industrial, medical, agricultural and civilian research applications.

International concern about the safety and security of radioactive sources, however, was not new. Accidents involving radioactive sources and reports of illicit trafficking in radioactive materials had already highlighted the potential vulnerability of radioactive sources, and had led to greater awareness of the safety and security risks created by sources that are outside effective regulatory control — or 'orphaned'.

Accordingly, in the early 1990s the IAEA initiated a number of actions regarding the safety and security of high risk radioactive sources (see the Appendix to this summary). In co-operation with other international organizations, it established the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources (the BSS), and, to support the implementation of these Standards, launched a Model Project for upgrading radiation protection infrastructure. More than 50 IAEA Member States have participated in this Model Project. In addition, the IAEA held a conference in Dijon, France, in 1998, that resulted in the establishment of an international Action Plan for the Safety and Security of Radiation Sources, and a conference in Buenos Aires, Argentina, in 2000, that resulted in the revision of the Action Plan. Implementation of the revised Action Plan has led to, inter alia, a categorization of radioactive sources and a Code of Conduct on the Safety and Security of Radioactive Sources, which are currently being revised. In addition, the IAEA established a programme to detect, intercept and respond to illicit uses of nuclear material and radioactive sources. The programme's achievements were the focus of an IAEA conference held in Stockholm, Sweden, in 2001.

In the aftermath of 11 September 2001, new concerns emerged regarding the potential use of high risk radioactive sources for malevolent purposes. In the light of those concerns, at the September 2002 session of the IAEA General Conference, United States Secretary of Energy Spencer Abraham proposed the convening of an international conference to promote information exchange on, and raise governmental and public awareness of, key issues relating to the security of high risk radioactive sources, as well as, in particular, to foster a better understanding of the measures necessary to improve the security of such sources and enhance preparedness for radiological emergencies. Many Member States and several international organizations responded positively to the proposal.

Thus the International Conference on Security of Radioactive Sources took place from 10 to 13 March 2003 at the Hofburg Palace in Vienna, Austria. Secretary of Energy Abraham presided over the Conference, which was co-sponsored by the Government of the Russian Federation and the Government of the United States of America and was hosted by the Government of Austria. It was organized by the IAEA in co-operation with the European Commission, the European Police Office (Europol), the International Criminal Police Organization (ICPO-Interpol) and the World Customs Organization (WCO).

The Conference resulted in a number of findings: the need to promote greater international co-operation in addressing the security concerns raised by insufficiently controlled radioactive sources, the need to identify those sources which pose the greatest risks, and the need for strong national action by all States to minimize those risks over the whole life cycle of the sources.

The Conference emphasized that, while it is important that co-operation in making available the beneficial uses of radioactive sources continue, all users of such sources share a responsibility for managing them in a safe and secure manner. Source manufacturers and regulators have important roles to play in that connection. The Conference also emphasized that the need for effective security arrangements should be balanced with the need to ensure the continued beneficial use of radioactive sources for the well being of humankind.

Governments worldwide and relevant international organizations are encouraged to review the following findings and to implement them.

FINDINGS OF THE PRESIDENT OF THE CONFERENCE

The Conference produced two major findings, as follows:

(1) High risk radioactive sources that are not under secure and regulated control, including so-called ‘orphan’ sources, raise serious security and safety concerns. Therefore an international initiative to facilitate the location, recovery and securing of such radioactive sources throughout the world should be launched under the IAEA’s aegis.

(The recent initiative of the Governments of the Russian Federation and the United States of America and the IAEA to secure radioactive sources in countries of the former USSR could serve as a model.)

(2) Effective national infrastructures for the safe and secure management of vulnerable and dangerous radioactive sources are essential for ensuring the long term security and control of such sources. In order to promote the establishment and maintenance of such infrastructures, States should make a concerted effort to follow the principles contained in the Code of Conduct on the Safety and Security of Radioactive Sources that is currently being revised (a draft revised version of which was presented to the Conference) as well as the security requirements in the BSS. In this context, the identification of the roles and responsibilities of governments, licensees and international organizations is vital. Therefore an international initiative to encourage and assist governments in their efforts to establish effective national infrastructures and to fulfil their responsibilities should be launched under the IAEA’s aegis, and the IAEA should promote broad adherence to the Code of Conduct once its revised version has been approved.

(The IAEA Model Project for upgrading radiation protection infrastructure could serve as a model.)

Additional findings of the Conference were as follows:

Identifying, searching for, recovering and securing high risk radioactive sources

The Conference encourages:

- The development and implementation by all States of national action plans, based on their own specific conditions, for locating, searching for, recovering and securing high risk radioactive sources, which should be part of the States’ strategies for the security of radioactive sources;
- Following further consultations with Member States, the accelerated establishment of a coherent and transparent scheme for the categorization

of radioactive sources, in order to provide for the safety and security of radioactive sources, and finalization of the Security of Radioactive Sources document currently in preparation;
— Countries with the necessary experience and capabilities to provide, as appropriate, assistance to other countries in identifying, searching for, recovering and securing high risk radioactive sources.

Strengthening long term control over radioactive sources

The Conference recognizes the Model Project on upgrading radiation safety infrastructure, now covering 88 Member States, as a powerful mechanism for assisting Member States in developing their infrastructures for the regulation and control of radioactive sources. The Model Project should be continued, and the IAEA should explore how the Model Project approach might be applied to non-Member States.

The Conference encourages:

— The formulation and implementation of national plans for the management of radioactive sources throughout their life cycle;
— The development, to the extent practical, of standards for the design of sealed sources and associated devices that are less suitable for malevolent use (i.e. alternative technologies, less dispersable forms of radioactive sources, etc.);
— The establishment of arrangements for the safe and secure disposal of disused high risk radioactive sources, including the development of disposal facilities;
— Once comments made by Member States are resolved (through the IAEA's relevant advisory mechanisms), the formal endorsement by the IAEA Board of Governors of the Code of Conduct on the Safety and Security of Radioactive Sources that is currently being revised;
— Support for the revised Action Plan for the Safety and Security of Radiation Sources, which has been an effective tool for helping Member States to strengthen the control of their sources;
— The IAEA to continue its work on clarifying the additional security measures that are required to address the issue of the malevolent use of high risk radioactive sources, in accordance with the risks that such sources present if used for malevolent purposes.

Interdicting illicit trafficking

The Conference acknowledges the need for greater international efforts to detect and interdict illicit trafficking in high risk radioactive sources and to take appropriate enforcement action.

The Conference encourages:

- The further development and strengthening of measures to detect, interdict and respond to illicit trafficking in high risk radioactive sources, and interaction between States and relevant international organizations to promote these objectives;
- The deployment and wider use of technologies for detecting high risk radioactive sources, with emphasis on ensuring the sustainability of monitoring and detection equipment;
- Further research on and development of detection technologies for use at borders and elsewhere, taking note of user friendliness, cost effectiveness and harmonization needs;
- Enhanced co-operation among governmental agencies responsible for preventing, detecting and responding to illicit trafficking incidents, especially in the fields of information sharing, communications and training;
- The pooling of resources by States, for example through the sharing of monitoring and detection equipment on common borders;
- Continued support for and development of the IAEA Illicit Trafficking Database, which can provide valuable input for the evaluation of trends.

Roles and responsibilities

The Conference notes that, while the international partners for developing an effective security system for high risk radioactive sources are governments, licensees and international organizations, in many countries there are national authorities responsible, on one hand, for the safety of radioactive sources and, on the other, for security related aspects of the prevention of malevolent activities involving such sources. States should therefore, as appropriate, establish effective legal and regulatory systems that clearly define roles and responsibilities relating to safety and security during all stages of the life cycle of radioactive sources. The Conference also notes that many countries still face difficulties with the storage or final disposal of disused radioactive sources, including those that are high risk.

The Conference encourages:

- The IAEA to continue supporting the Model Project for upgrading radiation protection infrastructure in order that developing Member States may be assisted in establishing sustainable radiation protection infrastructures, contributing to strengthening the security of high risk radioactive sources;
- The IAEA to promote close collaboration among governments, licensees and international organizations aimed at enhancing the security of high risk radioactive sources;
- Close collaboration among governments, licensees and international organizations in the area of the security of high risk radioactive sources;
- Collaboration in helping developing countries to properly manage their disused high risk radioactive sources.

Planning the response to radiological emergencies arising from the malevolent use of radioactive sources

Given the new scenarios presented by the possibility of the malevolent use of high risk radioactive sources, the Conference recommends that States develop comprehensive plans for preparing for and responding to radiological emergencies involving such sources.

The Conference encourages:

- Concerted efforts by all States and the IAEA to enhance current national and international response arrangements, taking account of the need to respond both proactively and reactively to the new scenarios presented by the possibility of the malevolent use of high risk radioactive sources;
- States to strengthen their mechanisms for the provision of international assistance, within the framework of the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (the Assistance Convention);
- States to consider establishing mechanisms to facilitate effective co-ordination in the event of a radiological emergency;
- The strengthening of communications between States and the IAEA's Emergency Response Centre;
- IAEA Member States, States Parties to the Assistance Convention and the IAEA Secretariat to clarify the roles that they would have to play in the event of a radiological emergency.

Role of the media, public education, communication and outreach

The Conference recognizes that the public's understanding of the nature and consequences of radiological emergencies will largely determine how the public reacts to such emergencies.

The Conference encourages:

— States to conduct proactive public outreach and awareness programmes to foster — among legislators, radioactive source users, the media and the public — a better understanding of radiological threats, and the appropriate response in the event of a radiological emergency in order to minimize social and economic disruption;
— Appropriate efforts by States to educate the public regarding the nature of radioactivity, the consequences of malevolent uses of high risk radioactive sources, and the procedures for mitigating those consequences in order to reduce the psychological impact of radiological terrorism;
— Governments to strengthen their education and training programmes as a means to promote confidence-building amongst the public;
— The assumption by States of greater responsibility for gaining the trust of the mass media and informing media representatives about the potential threat of radiological terrorism;
— The assumption by the mass media of greater responsibility for communicating accurate information, provided by authorities, in a non-sensational manner so as to avoid fuelling public fear and panic.

OUTLOOK

The Conference recommends that the IAEA, taking account of these findings, revisit the revised Action Plan for the Safety and Security of Radiation Sources and adjust it as appropriate.

The Conference concludes that the IAEA should organize a further conference in two years' time to assess progress regarding the worldwide security of high risk radioactive sources; this includes progress in the implementation of the Code of Conduct on the Safety and Security of Radioactive Sources currently being revised, in the further development of measures to protect high risk radioactive sources, and in the development and implementation of national strategies for regaining control over orphan sources. The conference should also assess further development needs in key areas.

Finally, the President of the Conference wishes to express deep appreciation for the sponsorship by the Governments of the Russian Federation and the United States of America, for the co-operation of the European Commission, the European Police Office, the International Criminal Police Organization and the World Customs Organization, for the organizational efforts of the IAEA and for the hospitality of the Government of Austria. He thanks all speakers and other participants, and their governments and organizations.

Appendix

HISTORICAL BACKGROUND REGARDING RADIOACTIVE SOURCE SAFETY AND SECURITY ACTIVITIES

International requirements relating to radioactive source security

1. In 1994, the IAEA Board of Governors approved the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources (the BSS), which established international requirements relating to the security of radioactive sources. The BSS require governments to establish national infrastructures for the proper control of radioactive sources, including systems of notification, registration, licensing and inspection. They also require that radioactive sources be kept secure, through measures ensuring, inter alia, that control over them is neither relinquished nor transferred improperly.

The Technical Co-operation Model Project

2. Also in 1994, the IAEA launched an unprecedented international co-operative effort to improve radiation safety infrastructures in more than 50 of its Member States within the framework of its Technical Co-operation programme. The objective of this Model Project was to establish national infrastructures compatible with the BSS requirements in Member States receiving IAEA technical assistance. After a decade, about three quarters of the countries participating in the Model Project have the necessary laws promulgated and regulatory authorities established, about half have the necessary regulations adopted and systems for the notification, authorization and control of radioactive sources in place and operational, and a large majority have radioactive source and radiation installation inventory systems in place and operational. The Model Project is currently being expanded to cover more than 80 Member States of the IAEA.

The Dijon conference

3. In September 1998, the IAEA held an International Conference on the Safety of Radiation Sources and Security of Radioactive Materials in Dijon, France. The Dijon conference was co-sponsored by the European Commission, the International Criminal Police Organization (ICPO-Interpol) and the World Customs Organization (WCO). Some of the Dijon conference's findings were

of particular relevance to the current concerns about the security of radioactive sources.[1]

4. In September 1998, the IAEA General Conference noted with interest the major findings of the Dijon conference and encouraged all governments "to take steps to ensure the existence within their territories of effective national systems of control for ensuring the safety of radiation sources and the security of radioactive materials". Also, it requested the IAEA Secretariat to report on (i) how national systems for ensuring the safety of radiation sources and the security of radioactive materials can be operated at a high level of effectiveness, and (ii) whether international undertakings concerned with the effective operation of such systems and attracting broad adherence could be formulated. In March 1999, the Board of Governors requested the IAEA Director General to bring the report prepared in response to the General Conference's request to the attention of national authorities by distributing it

[1] The findings of the Dijon Conference conference of particular relevance for the security of radioactive sources are the following: regulatory infrastructures for the control of radiation sources must be supported by governments and be able to act independently, and the regulatory authority in each country must maintain oversight of all radiation sources in that country, including those which have been imported; radioactive sources should not be allowed to drop out of the regulatory control system, which means that the regulatory authority must keep up to date records of the person responsible for each source, monitor transfers of sources and track the fate of each source at the end of its useful life; efforts should be made to find radiation sources that are not in the regulatory authority's inventory, because they were in the country before the inventory was established, or were never specifically licensed or were lost, abandoned or stolen; as there are many such orphan sources throughout the world, efforts to improve the detection of radioactive materials crossing national borders and moving within countries by carrying out radiation measurements and through intelligence gathering should be intensified; the key common element which would have the greatest part to play both in the avoidance of orphan sources, with their potential for misuse, and in the achievement and maintenance of secure conditions, is an effective national regulatory authority operating within a suitable national infrastructure; governments should create regulatory authorities for radiation sources if they do not exist; whether the regulatory authority is newly created or has been in existence for some time, the government must provide it with sufficient backing and with sufficient human and financial resources to enable it to function effectively, for only in this way can the problem of source security be tackled at its roots and eventually brought under control; and efforts should be made to investigate whether international undertakings concerned with the effective operation of national regulatory control systems and attracting broad adherence could be formulated.

to all States, encouraging them, inter alia, to (i) establish or strengthen national systems of control for ensuring the safety and security of radiation sources, particularly legislation and regulations and regulatory authorities empowered to authorize and inspect regulated activities and to enforce the legislation and regulations; (ii) provide their regulatory authorities with sufficient resources, including trained personnel, for the enforcement of compliance with relevant requirements; (iii) consider installing radiation monitoring systems at airports and seaports, at border crossings and at other locations where radiation sources might appear (such as metal scrapyards and recycling plants); (iv) develop adequate search and response strategies; and (v) arrange for the training of staff and the provision of equipment to be used in the event that radiation sources are detected.

The first international Action Plan dealing with the security of radioactive sources

5. As a further follow-up to the Dijon conference, the Board of Governors requested the Secretariat to prepare an international Action Plan. It approved the international Action Plan for the Safety and Security of Radioactive Sources in September 1999. At the same time it requested the Director General to initiate exploratory discussions relating to an international undertaking in the area of the safety and security of radiation sources, it being understood that the international undertaking should provide for a clear commitment by and attract the broad adherence of States.

Categorization of Radiation Sources and Code of Conduct

6. In September 2000, the Board of Governors invited Member States to draw on a recently developed Categorization of Radiation Sources which was subsequently issued as IAEA-TECDOC-1191. Also, the Board requested that a recently developed Code of Conduct on the Safety and Security of Radioactive Sources be circulated to all States and all relevant international organizations, and called for consultations on decisions which the IAEA policy making organs might wish to take regarding the application and implementation of the Code of Conduct.

The Buenos Aires conference

7. In December 2000, the IAEA held an International Conference of National Regulatory Authorities with Competence in the Safety of Radiation Sources and the Security of Radioactive Materials in Buenos Aires, Argentina.

Most of the findings of the Buenos Aires conference were relevant to the security of radioactive sources.[2] In March 2001, the Board of Governors noted the major findings of the Buenos Aires conference and requested the Secretariat to assess their implications for the Action Plan. A revised Action Plan was — ironically — adopted by the Board on 10 September 2001, one day before the terrorist attacks on New York and Washington, DC.

The Stockholm conference

8. The IAEA held an International Conference on Measures to Detect, Intercept and Respond to the Illicit Uses of Nuclear Material and Radioactive

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[2] The Buenos Aires conference concluded that knowledge is the initial essential component in achieving the required safety and security of radiation sources, and education and training are the most important pathways leading to their achievement. It therefore requested States to establish strategies for the education and training of regulatory staff, including the on-the-job training of inspectors in the most relevant radiation practices and of radiation users in the management of radiation sources, and, in the case of those States which have fully developed radiation protection infrastructures, to participate more actively in the education and training of people from developing countries.

The Buenos Aires conference recognized that a considerable number of States were still having difficulties in establishing fully effective systems for the regulatory control of radiation sources and called upon regulatory authorities to establish a single national source registry. Moreover, it recommended that the operational lifetime of radiation sources and of the devices into which they are incorporated be stated in the accompanying documentation, and that regulatory authorities should take measures to ensure the continuity of control over radiation sources during that period, further indicating that national regulatory authorities should impose on users, suppliers, manufacturers, etc., the responsibility for maintaining continuity of control over each source during the period specified in the authorization for its use. It requested States to establish inventories of disused sources and to ensure that disused sources are kept in an appropriate storage facility if returning them to the supplier or sending them to a disposal facility is not feasible, underlining that temporary storage by the user should be minimized, and that financial provision should be made, with governmental support if necessary, for taking care of sources after the declared use has been completed.

Several findings of the Buenos Aires conference related to the issue of orphan sources, requiring governments to ensure that arrangements are made between regulatory authorities and facility operators for the detection and future handling of orphan sources. States were requested to develop national strategies for searching for and localizing orphan sources, including actions to bring sources that are in a vulnerable state (e.g. in inadequate storage) under proper control; programmes for investigating (e.g. monitoring)

Sources in Stockholm, Sweden, in May 2001. The Stockholm conference was organized by the IAEA in co-operation with the European Police Office (Europol), ICPO-Interpol and the WCO. It focused on measures to reduce the possibility of illegal activities such as theft, sabotage and trafficking involving nuclear materials and other radioactive materials, and on the associated proliferation threat and radiation risks. Some of the observations and conclusions are relevant for the security of radioactive sources.[3]

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sites where the presence of abandoned sources is suspected; detection systems (at border crossings, scrapyards, foundries, steel mills, landfill sites and incineration plants); intelligence gathering (for cases of illicit trafficking); arrangements for responding to abnormal events which do not necessarily constitute emergencies (e.g. the finding of a radiation source); and arrangements for dealing with users who have gone bankrupt.

Most significantly, the Buenos Aires conference addressed the issue of criminal activities involving radioactive materials, well before the 11 September 2001 events made this a significant issue at the policy making level. It recommended that measures to prevent the criminal misuse of radiation sources be seen as complementary to measures to increase their safety and security and that events where individuals are exposed to radiation because of breaches in radioactive source safety or security without malice aforethought should be clearly distinguished from events where there is a criminal intent of exposing people to harmful effects of radiation. The prevention of criminal activities involving radioactive sources requires, according to the Buenos Aires conference, broader competence and a thorough understanding of the related issues, and closer co-operation at the national and the international level between nuclear regulatory authorities and law enforcement authorities (police, customs and intelligence) is therefore essential.

[3] The Stockholm conference concluded that: a comprehensive approach to security of material is warranted, taking into account both the risks for nuclear proliferation through the potential use of nuclear material in nuclear devices and the threat to radiation health and safety; States have the responsibility to ensure that their regulatory systems cover the measures required for prevention, detection and response to threats coming from theft, sabotage or other illegal activities involving nuclear and other radioactive materials; improved methodology, improved information and improved co-operation with competent national and international organizations would contribute to improving threat assessments and developing security measures; and continued efforts are required at the national and international levels and that increased support is needed for States establishing the necessary technical, administrative and regulatory measures. The Stockholm conference recognized that the IAEA has a key role in supporting State efforts to improve the security of material and combat illicit trafficking by providing guidance and normative documents, promoting technical development and, upon request, assisting States in their implementation.

Post-11-September-2001 actions

9. The 11 September 2001 terrorist attacks in the USA led to implementation of the revised Action Plan taking place in conjunction with efforts to strengthen the IAEA's work relevant to preventing acts of terrorism involving nuclear materials and other radioactive materials. In March 2002, the Board of Governors had before it proposals made by the Director General for activities in the area of nuclear security which included a full set of activities relating to the security of radioactive sources. The Board supported the establishment of an extrabudgetary fund to be financed through voluntary contributions. Also, it noted that the IAEA's Technical Co-operation programme could be an important mechanism for implementing some activities.

10. In September 2002, the General Conference considered a report by the Director General entitled Nuclear Security — Progress on Measures to Protect against Nuclear Terrorism. It noted the arrangements implemented to provide funding for a Nuclear Security Fund through voluntary contributions and called upon all Member States to continue to provide political, financial and technical support, including in-kind contributions, to improve nuclear security and prevent nuclear terrorism, and to provide to the Nuclear Security Fund the political and financial support it needed. Also, it welcomed, inter alia, the activities for the prevention and detection of and response to illicit activities involving radioactive materials undertaken by the IAEA to improve nuclear security and prevent nuclear terrorism, and the IAEA's programmes and renewed efforts to assist States in establishing and strengthening systems of radiation protection appropriate to their circumstances, possibly including national registries of radioactive sources. In particular, it commended the Secretariat and Member States for the progress that had been made in upgrading radiation protection infrastructures through the Model Project and commended the Secretariat for the action it had taken in a number of countries, in co-operation with Member States, to locate, secure and remove orphan sources. The General Conference urged IAEA Member States to strengthen their national efforts to secure all radioactive sources within their borders, and invited them to take note of the Code of Conduct on the Safety and Security of Radioactive Sources and to consider means of ensuring its wide application. In addition, it welcomed the activities undertaken to provide for an exchange of information with Member States, including continued maintenance of the IAEA's Illicit Trafficking Database programme, and to improve information exchange by making the best use of the modernized database, and it invited all States to participate in the Illicit Trafficking Database programme on a voluntary basis.

CLOSING REMARKS

T. Taniguchi
Deputy Director General, Department of Nuclear Safety and Security,
International Atomic Energy Agency, Vienna

The proposal from United States Secretary of Energy Abraham for the IAEA to organize this conference was prompted by security concerns over the possible malevolent use of radioactive sources, concerns that were heightened following the tragic events of 11 September 2001. However, this conference also builds upon a solid legacy from the earlier Dijon, Buenos Aires and Stockholm conferences. In these three days we have surveyed the entire spectrum of security issues related to radioactive sources. This afternoon the conference President has presented his findings, which will be made available immediately on the IAEA web site. I will refer to these findings in my presentation to the Board of Governors, which meets next week.

We will eagerly work with our Member States to follow up these findings and convert them into concrete actions. In particular, we shall review our action plans on safety and security and make recommendations to the Board on any further actions that are necessary. I believe we now have a much clearer understanding of the issues involved in meeting the new challenges posed by the new perceptions and concerns relating to the security of radioactive sources.

Before I turn to specifics, I should like to mention four general points concerning the IAEA's approach to meeting these challenges.

Firstly, I believe this is a field in which safety and security have to go hand in hand, as mutually reinforcing parts of the solution. There will be considerable benefit in bringing together the different perspectives, approaches and cultures related to the safety and security of radioactive sources.

Secondly, we need to address the issue in a factual and scientific manner, informing people objectively and honestly about the consequences of the malevolent use of radioactive sources without giving rise to excessive fears and panic.

Thirdly, we must not lose sight of the tremendous benefits that radioactive sources confer in many applications in medicine, industry, agriculture and research. We must deal with the security issues, but in doing so we must not unduly hinder the delivery of these benefits.

Fourthly, we must focus our efforts on identifying and strengthening the protection of those high risk sources that could be vulnerable to use in malevolent acts.

Therefore, in line with the findings of this conference, the IAEA Secretariat will continue to commit its resources and efforts to supporting international initiatives:

— To facilitate throughout the world the locating, recovering and securing of high risk radioactive sources that are not secure and not under proper regulatory control (including the 'orphan' sources).
— To encourage and assist governments to establish long term effective national infrastructures for the safe and secure management of vulnerable and dangerous radioactive sources from cradle to grave, including their ultimate disposal; and to promote broad adherence to the Code of Conduct on the Safety and Security of Radioactive Sources.

To this end, the Secretariat will continue its consultations with Member States, with the aims of:

(1) Proceeding to the formal endorsement by the Board of Governors of the Code of Conduct on the Safety and Security of Radioactive Sources and the Categorization of Sources, which are currently being revised.
(2) Accelerating the development of additional documents to provide a common and technically sound basis for national and international actions.
(3) Supporting States in establishing effective legal and regulatory systems that clearly define the roles and responsibilities, during all stages of the life cycle of radioactive sources, relating to safety and security and to the prevention of criminal activities; and continuing to work on the long term management and disposal of disused sources.

The Secretariat will further support greater international efforts to help States to prevent, detect, interdict and respond to illicit trafficking in radioactive sources and to take appropriate enforcement action.

Finally, the Secretariat also stands ready to help States to develop comprehensive plans for preparedness for and response to radiological emergencies, taking into account the new scenarios presented by high risk radioactive sources.

Many people have co-operated to make this conference successful, in some cases within very short time constraints. We appreciate the strong leadership of the President as well as the session chairs, the careful preparation on the part of the speakers and the overall guidance of the Programme and Steering Committee, which planned the programme and chose the speakers.

I should also like to acknowledge with particular gratitude the highly professional and dedicated assistance of the interpreters, technicians, Conference Services staff and support staff of the IAEA and the Hofburg. I hesitate to mention specific names for fear that I will omit someone. Nevertheless I would like to express my deep gratitude to five people in particular for their extreme dedication: Tom Dolan, Birgitt Eder-Amstler, Vilmos Friedrich, Thussi Niedermayer and Regina Perricos.

In closing, I would wish to express my sincere appreciation for the sponsorship of the conference by the Governments of the Russian Federation and the United States of America, for the warm hospitality of the Government of Austria, and for the co-operation of the European Commission, the European Police Organization, the International Criminal Police Organization and the World Customs Organization.

This conference can only be considered very successful if its findings are translated into effective actions. This we intend to do. But we cannot do it on our own; we need your support. One proposal was for another conference to be held in the two years to continue the important work of this conference. This proposal we will pursue in consultation with Member States and interested international organizations.

In conclusion, I should like to say how impressed I have been by the lively discussions that have taken place during this conference and by the great interest shown by the conference participants in ensuring that radioactive sources throughout the world are kept secure.

ANNEX

APPLICATION OF SOURCES OF IONIZING RADIATION IN VARIOUS FIELDS OF THE RUSSIAN ECONOMY AND PROCEDURES FOR THEIR UTILIZATION

V.P. NESTEROV, B.V. AKAKIEV, I.M. MAKAREVICH
Federal State Unitary Enterprise,
All-Regional Corporation Izotop (FGUP V/O Izotop),
Ministry of the Russian Federation for Atomic Energy

B.M. VANYUSHKIN
All-Russian Scientific Research Institute of
Technical Physics and Automation (VNIITFA)

A.S. BARINOV, A.S. VOLKOV
Joint Environment Technology and Scientific
Research Center (MosNPO RADON)

M.V. MIKHAILOV
Federal Nuclear and Radiation Safety Authority of the
Russian Federation (Gosatomnadzor)

Moscow, Russian Federation

Abstract

The paper discusses radionuclides commonly used as sources of ionizing radiation, fields of application of radioactive sources, the decommissioning of spent sources, and procedures to be followed in the Russian Federation for the application of radioactive sources.

1. COMMONLY USED RADIONUCLIDES AND THE RADIOLOGICAL DANGER OF IONIZING SOURCES

At present, of the 1700 known radionuclides, of which 90 are natural and the others made in nuclear reactors and accelerators, only 160 radionuclides of 80 chemical elements have found practical application in the Russian Federation [1]. Powerful sealed radioactive sources mainly use $^{90}Sr + {}^{90}Y$, ^{137}Cs, ^{60}Co, ^{192}Ir, ^{238}Pu, ^{239}Pu, ^{252}Cf, ^{241}Am, which along with some others are the radionuclides belonging to the first category according to IAEA-TECDOC-

1191 [2]. The Russian Federation produces (the main manufacturer is Mayak Production Association in Ozyorsk) over 2000 types of ionizing sources, of which about 200 types are widely used.

In the past, cases of illegal use of ionizing sources were occasionally registered in the Russian Federation. After the Russian Criminal Codex adopted a punishment of two to six years of imprisonment for illegal use of radioactive substances, we know of only two cases where sources of ionizing radiation were used for terrorist purposes: the placement of a container with a ^{137}Cs source with an activity of about 5 Ci (1 Ci = 37 GBq) in Izmaylovo Park in Moscow, and the placement of a ^{60}Co source from a γ therapy apparatus near a federal road in Grozny. From time to time authorities have found orphan spent ionizing sources and asked the All-Regional Corporation Izotop (FGUP V/O Izotop) of the Ministry of the Russian Federation for Atomic Energy and the Joint Environment Technology and Scientific Research Center (MosNPO RADON) to identify their owners.

The most dangerous radioactive sources from the point of view of permissible content in water and in air are the α emitting nuclides ^{137}Cs and ^{90}Sr. Usually the radioactive sources with ^{137}Cs contain finely dispersed salts of caesium nitrate and caesium chloride. This material is very volatile and aggressive and is easily soluble in water in the event of capsule failure. Before 1970 the sources were manufactured in aluminium capsules and then in double capsules of stainless steel. About ten years ago such a source became unsealed near Moscow, which resulted in contamination of the area at Klyasma settlement and of a pool.

The concentration limit for ^{137}Cs in water is 5×10^{-10} Ci/L. About 1 Ci of ^{137}Cs can contaminate more than 5×10^5 m^3 of water, i.e. it is enough to contaminate the water supply at any water station.

Less dangerous are the sources using ^{60}Co, which is made into metal pellets placed in a double capsule of stainless steel.

2. FIELDS OF RADIOACTIVE SOURCE APPLICATION

Equipment with radionuclide sources is widely used in many fields of the economy: the nuclear and energy industries, metallurgy, geology, mining, ecology, metrology, chemistry, oil and gas industries, medicine and agriculture. The main equipment types are:

- Radioisotope thermoelectric generators (RTGs) for autonomous energy supply for various devices in inaccessible or remote areas (beacons and radar, weather stations and so on) [3];

— Radiation and technological units for treatment of medical, agricultural and industrial products, for modification of materials by γ radiation and so on [4, 5];
— γ therapeutic devices (treatment of cancer);
— Non-destructive testing devices (γ defectoscopes);
— Industrial gauges (densitometers, level gauges, thickness gauges and devices for analysis of the composition of materials).

From the point of view of radiological terrorism, the systems with the largest amount of radioactive material are the most dangerous. Typical systems of this kind are RTGs.

2.1. Radioisotope sources of electric power

At present there are a few hundred RTGs of various types, which were emplaced 15–20 years ago in the areas of the North and Far East and in the countries of the former Soviet Union for autonomous power supply in various devices. The lifetime of most of them is over. Each system includes 30 to 100 or more kilocuries of $^{90}Sr + ^{90}Y$, and the total activity amounts to more than 40 MCi [4].

Some cases of illegal unsealing of RTGs by the inhabitants to use the coloured metals (in Kazakhstan, Georgia, Kandalaksha (North of the Russian Federation) and Tajikistan) took place and resulted in high doses of radiation and even in death. To bring RTGs under control, it is planned to remove them from the inaccessible and remote places in the Russian Federation and in particular from the Arctic Ocean region. The required normative documents have been elaborated, and the technology for RTG removal and utilization has been determined.

2.2. Industrial and research applications

Various types of research irradiators are potentially dangerous. The first γ emitting system in the Russian Federation was developed 47 years ago [5]. Investigations show that the Russian Federation and the countries of the former Soviet Union have more than 250 such irradiators of various types.

According to the field of application, the irradiators are divided into radiobiological, radiophysical and radiochemical types. The most advanced radiobiological technology includes such processes as sterilization of materials and medical products, treatment of food products, cleaning of water and industrial effluents, and pest control. Radiophysical units are used for upgrading the characteristics of microprocessor elements.

Radiochemical technology includes changing the structure and features of mono- and polymeric materials (polymerization and so on).

The irradiators use various sources of ^{60}Co and ^{137}Cs. There is a large variety in design, from small laboratory types to large industrial plants; for example, a laboratory system for microbiological and biochemical investigations has a mass of 800 kg and includes 24 sources with ^{137}Cs and a total activity of 2900 Ci.

Since 1965 scientific institutes have used γ irradiators of the PMX-γ-100 type, with 96 ^{137}Cs sources, to carry out microbiological and radiochemical investigations. The mass of the unit is 5.5 t, and the dimensions are 1.26 m × 1.4 m × 1.6 m [6]. PXM-γ-30 and Investigator units, with ^{60}Co and a total activity of up to 30 kCi, are widely used. To simulate radiation from space, about 100 irradiators with ^{60}Co and ^{137}Cs were manufactured, each containing sources with an activity of up to 5200 Ci [7].

Industrial plants for radiochemical technologies and sterilization of materials and products represent complicated engineered complexes with working chambers, labyrinths, and additional mechanisms and premises. Concrete walls with a thickness of 1.7–2.0 m provide radiation shielding of the working chamber. Such plants include some hundreds of ^{60}Co sources, with a total activity of up to 1200 kCi.

2.3. γ therapeutic devices

At present the Russian Federation operates about 300 medical γ therapy machines for teletherapy and brachytherapy (AGAT and ROKUS). These machines contain sources with ^{60}Co. Brachytherapy machines contain from three to seven sources with a total activity of up to 3 Ci; teletherapy machines contain one source with an activity of up to 80 kCi. The sources are replaced every five years.

The total activity of ^{60}Co sources in γ therapeutic machines is currently estimated as 1.5 MCi.

2.4. Industrial gauges

At present the Russian Federation operates some tens of thousands of technological control devices of more than 20 types. They are used to measure humidity, density, and the level of material in blast furnaces and of coal in vehicles [8]. Each device uses γ sources of different types. They contain one ^{137}Cs source with an activity of up to 6.6 Ci [9].

Despite the relatively low activity of these sources, they are subjected to illegal activity very often, because there is no physical protection in place for these devices. A single coal mine uses 200 radioisotope devices to control vehicle loading.

Gamma defectoscopes, which are used for industrial radiography, use ^{60}Co, ^{75}Se, ^{170}Tm and ^{192}Ir. The application of neutron sources with ^{241}Am, ^{244}Cm and ^{252}Cf and the β emitting radionuclides ^{90}Sr + ^{90}Y, ^{147}Pm and ^{204}Tl in radiography is limited.

The most frequently applied sources use ^{192}Ir and ^{75}Se. The range of activity of sources with ^{192}Ir is 50–300 Ci; the activity of sources with ^{75}Se is from 3 to 120 Ci.

Neutralizers of static electricity using Pu + Be sources with an activity of up to 10 mCi pose some hazard. There are about 40 000 such neutralizers, and they are widely used in the production of items made of cotton, silk or polymeric threads, and in printing. The physical protection of the sources is not always ensured.

Other types of widely used devices (various analytic devices, smoke detectors) include sources with low activity and are scarcely dangerous from the point of view of terrorism.

3. DECOMMISSIONG OF DISUSED AND SPENT SOURCES

When IAEA General Conference Resolution No. GC(42)/RES/12 of 25 September 1998 was adopted, the Russian Federation began work on decommissioning the spent radioactive sources on its territory. An inventory of RTGs and irradiators was carried out. Their technical condition was analysed and the methods of decommissioning were determined. The procedure for decommissioning spent sources is described by the normative documents of the Federal Nuclear and Radiation Safety Authority of the Russian Federation (Gosatomnadzor).

When the Russian enterprises were privatized, the ownership of γ irradiators became unclear, because, according to Act 5 of the Federal Law on Nuclear Energy Application, radioactive sources can only be federal property. Only three years ago the law was amended, and now spent radiation sources can be owned by legal persons.

For a number of reasons many irradiators are either not used at full capacity or are not used at all. This is due principally to the absence of funds to replace the sources with new ones and to a change in the profile of the activity of the enterprises. Some new owners refuse to control spent irradiators located on their property. This results in a lack of proper physical protection of the systems.

At present more than 40 irradiators are to be put out of operation, and the sources have to be unloaded and stored. At the moment, the total number of sources that are to be removed and stored includes more than 5000 items using ^{60}Co and about 1000 items using ^{137}Cs. The removal of ^{137}Cs sources is complicated owing to the design of the irradiators, as their further decommissioning was not foreseen.

4. PROCEDURES FOR THE APPLICATION OF RADIOACTIVE SOURCES

The Russian Federation has well developed design standards for radioactive sources. The requirements for working with and ensuring the safety of radioactive sources are given in Federal Rules, such as Basic Rules for the Safety of Radioactive Sources (NP-032-02) and various Sanitary Rules, such as Sanitary Rules for Management of Radioactive Waste (SPORO-2002). These regulate the management of spent radioactive sources, which are considered as radioactive waste.

Transport is a very important step from the safety point of view and is considered as one of the potentially dangerous phases of source application. Radiation safety during transport can be provided by administrative and engineering measures. Among the normative documents for radioactive source transport are Rules of Dangerous Cargo Transport with Vehicles (PPOGAT-95), Rules of Safe Transport of Radioactive Materials (PBTRV-73) and the IAEA Regulations for the Safe Transport of Radioactive Material [10]. The basic statements of PPOGAT-95 include the requirements of the European Agreement on the international transport of dangerous goods (DOPOG), which are based on the IAEA Transport Regulations [10].

It is important to harmonize national safety rules of transport with international requirements. This task must be solved according to the obligations of the Russian Federation, as a Member State of the IAEA, that resulted from the Resolution of the 44th IAEA General Conference, held in September 2000, on Measures to Strengthen International Co-operation in Nuclear, Radiation and Waste Safety.

It should be pointed out that the Russian Federation has not had any serious incident during the transport of radioactive sources in the 50 years of their production and application. This is primarily due to the very stringent requirements for organizing transport and for shipping containers. Technical safety provisions are the most effective because they do not depend on human factors and are based on a conservative approach for designing the shipping capsules, shielding containers and transport packages to withstand mechanical and heat shocks in the event of an accident.

Despite the vast positive experience in providing for the safety of radioactive sources in transport by technical measures, organizational measures also play a significant role in terms of expenses. FGUP V/O Izotop is a large supplier and transporter of radioactive materials in the European part of the Russian Federation. More than 32 000 radioactive packages are delivered annually. The share of the different means of transport is as follows: 20% railway, 30% road vehicle and 50% air.

Vehicle transports are carried out with special vehicles of FGUP V/O Izotop and Moscow SIA RADON, as well as with vehicles of the manufacturers, on routes authorized by the respective departments of the Ministry of Home Affairs.

In 2001–2002, experts of the All-Russian Scientific Research Institute of Technical Physics and Automation (VNIITFA) and the firm Radiy, with the participation of experts from FGUP V/O Izotop, decommissioned 15 irradiators and delivered for storage in Mayak and RADON facilities more than 1200 sources with ^{60}Co and ^{137}Cs and a total activity of about 1.0 MCi. In the process of decommissioning irradiators whose lifetime had exceeded 3–6 times the planned one, problems of source removal arose. It was necessary to develop a procedure for source removal and to produce special tools.

Most spent radioactive sources are delivered to the special enterprise RADON and the manufacturer Mayak. For RADON, the average radionuclide composition of the delivered spent sources is ^{137}Cs (40%), ^{90}Sr + ^{90}Y (22%), ^{60}Co (20%), ^{192}Ir (8%) and ^{170}Tm (4%). Spent radioactive sources with a half-life of up to 30 years are kept in near surface storage in shipping containers.

The reference design of the stores was developed at the end of the 1950s and now it does not meet the requirements for safe disposal/storage of spent radioactive sources. In cases where the conditions of storage are unsatisfactory, departments of Gosatomnadzor makes decisions about the temporary cessation or complete banning of the disposal of the sources.

The safety assessment of such repositories in the Russian Federation and in the countries of the former Soviet Union demonstrated the possibility of the accelerated failure of the engineered barriers in conditions of powerful radiation fields, uneven heat removal, increasing concentration of dangerous radiolysis gases, and possible damage to protective barriers for different reasons. This results in possible penetration of radionuclides into underground waters and the surrounding soil. Radionuclides can also penetrate in the gas–aerosol phase through the repository loading channel into the environment. The data obtained showed that powerful spent sources cannot be stored without containers in near surface repositories, and it is necessary to change the technological arrangements for their handling.

The RADON enterprise stores powerful spent sources in structures designed for the disposal of sources without containers. The structure consists of a vessel made of stainless steel, with a volume of 0.5–1 m^3, placed at a depth of 3.5–6 m. It connects to the surface through a spiral channel, which is ended with the head and a hopper. Spent sources which are transported in shipping containers of the B(U) type with bottom unloading are emptied through the hopper and the spiral channel into the vessel [11]. This is called well type storage.

To provide long term safety of the well type storage, Moscow SIA RADON developed a technique for inclusion of spent sources in a metal matrix directly in the storage vessel that allows the use of a traditional emplacement scheme. Newly developed test procedures make it possible to determine the activity of spent sources in the storage vessel, the amount of vessel content, the dose rate on the head of the well and in the vessel, the contamination of the loading channel, and the presence and amount of hydrogen in the gaseous phase.

The immobilization technology permits the incorporation of spent sources in the matrix material and their homogeneous distribution in the vessel. The matrix material reduces the radiation and temperature loading on the structural elements of the storage. This also results in an increase in storage capacity by a factor of 6 (in terms of spent source activity).

The process of conditioning spent sources into metal matrices can be carried out by the mobile plant Moskit. Moskit makes it possible to use traditional technology for source emplacement into the storage and to carry out conditioning directly in the underground vessel. The plant design includes a connecting module and a gas purification system, which make it possible to isolate the interior of the storage from the atmosphere and to exclude radionuclide release into the environment owing to the creation of a negative pressure. A melt of matrix material is prepared in a special module outside the storage vessel. This results in decreasing the period of heat influence on the spent sources to a minimum. The overheated melt is poured along a flexible heatproof sleeve and loaded into the storage through the loading channel, into the underground vessel. Lead based melts are the most promising matrix materials for spent source conditioning. Moskit carries out all the tasks from the testing of storage conditions, water or condensate pumping, vessel drying with hot air and spent source immobilization in the metal matrix. When all operations are completed, the storage is ready to begin a further operation.

Detailed analysis of safety during the emplacement of spent sources in well type storage, carried out by Moscow SIA RADON in 1998–1999, demonstrated that this technology provides safe isolation of the spent sources from the environment for the whole period of their storage — up to 500 years.

Complete flooding of the storage leading to a release of radioactivity will result in an increase in the total annual population dose of not more than (5.5–7.5) × 10^{-5} Sv/a. This has been proven by safety estimation calculations carried out with the MASCOT(1) program, according to which this value does not exceed 10^{-8} Sv/a [12].

This plant and the spent source immobilization technology have been used at RADON enterprises in Volgograd, Ekatherinburg, Nizhny Novgorod and Ufa. The technology described for spent source immobilization can be used for the storage of ionizing sources with long lived radionuclides (^{226}Ra, ^{239}Pu and so on). The Russian Federation has developed a conventional package, NZK-150-1,5P, with which spent source conditioning, transport and disposal in deep geological formations can be carried out.

5. CONCLUSIONS

On the basis of this paper it can be concluded that the Russian Federation has a normative and engineering base for the management of radioactive sources which makes it possible to decommission disused plants and items with spent sources in a short time and to provide for their temporary storage and disposal.

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ACCOUNTING AND CONTROL OF SOURCES OF IONIZING RADIATION AND RADIOACTIVE MATERIALS

V.V. SHATALOV, S.N. BRYKIN, I.S. SEREBRYAKOV, S.A. YAKUSHEV
All-Russian Scientific Research Institute
of Chemical Technology,
Moscow, Russian Federation
E-mail: shatalov@vniiht.ru

Abstract

In the Russian Federation, the accounting and control of sources of ionizing radiation and radioactive materials is the responsibility of the Ministry of the Russian Federation for Atomic Energy. The paper describes the various elements of the accounting and control system and some of the tasks to be carried out for the development and improvement of the system.

The accounting and control of sources of ionizing radiation and radioactive materials is a national problem that comes under the responsibility of the Ministry of the Russian Federation for Atomic Energy (Minatom) (the main performer), federal organs, and executive authorities and their organs. In accordance with the Resolution Dated 11 October 1997, No. 1298, on Approving the Rules for Organization of the System of State Accounting and Control of Radioactive Materials and Radioactive Waste, two State systems have been created and developed in the Russian Federation, for:

— accounting and control of nuclear materials;
— accounting and control of radioactive materials and radioactive waste.

From the moment of their arrival in the end product store of the producer and during their movement up to the time of storage (disposal), sources of ionizing radiation are accounted for within the framework of the State system for accounting and checking of radioactive materials and radioactive waste.

The specified systems are being developed under the supervision of Minatom. The Department of Safety, Ecology and Emergency Situations of Minatom carries out direct management of the State system of accounting and control of radioactive materials and radioactive waste. In accordance with decree GUP VNIIHT, specialized subdivisions are entrusted with the functions of the collection, processing and analysis of information.

In accordance with specified rules, Minatom carries out within the framework of its own authority:

(1) Accounting and checking of radioactive materials and radioactive waste at the federal level;
(2) Development of the general engineering design of the accounting and control system together with other interested organs;
(3) Work connected with the creation, operation, methodical support and improvement of the accounting and checking system as well as the creation of interdepartmental commissions for co-ordination of activities in this area;
(4) Presentation of information about the presence and movement of radioactive materials and radioactive waste as well as about their export and import to the organs of the State authorities, the federal organs of executive authorities implementing the national regulation of the safe use of atomic energy, the Ministry of Civil Defence Affairs, Emergency Situations and Liquidation of Natural Disaster Consequences, the Federal Service of Safety, the State Committee for Environmental Protection, and other relevant bodies;
(5) Collection and analysis of information about accounting and checking of nuclear materials and radioactive waste at the regional and departmental levels;
(6) Development of federal approved standards and rules for the accounting and control of nuclear materials and radioactive waste together with federal organs of the executive authorities involved;
(7) Scientific, methodological and technical developments in the field of creation, operation and improvement of the accounting and control system at the federal, regional and departmental levels;
(8) Co-ordination of the work of the federal organs of executive authorities on preparing the normative legislation ensuring accounting and checking of nuclear materials and radioactive waste;
(9) Activities related to information-analytical organizations and centres for the collection, processing and transfer of information on operating the accounting and checking system at the federal level;
(10) Development and approval of standard forms for the accounting and checking of radioactive materials and radioactive waste in accordance with established orders at the federal, regional and departmental levels.

An organizational–functional scheme of the system is presented in Fig. 1.

In accordance with the rules set by a resolution of the Russian Government, regional information-analytical centres and departmental centres

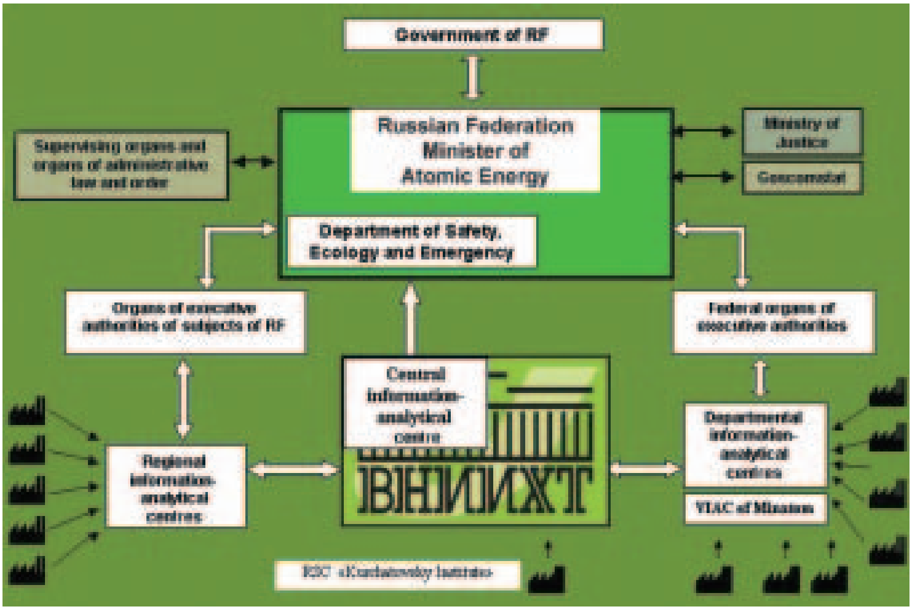

FIG. 1. Organizational–functional scheme of the system for accounting and control.

(in federal organs of executive authorities, the Russian Academy of Sciences) must work within the system.

So far, 56 regional and 18 departmental information-analytical centres have been established and are functioning.

All organizations (enterprises) engaged in the production, transport, use, storage, treatment and disposal of radioactive sources have to be included in the system. At present the system includes more than 2000 organizations.

Operation of the State system for accounting and control of radioactive materials and radioactive waste is provided by the main normative legal and methodical documents, prepared by Minatom:

(a) Rules of organization of the system of State accounting and control of radioactive materials and radioactive waste.
(b) Regulations for State accounting and control of radioactive materials and radioactive waste in the Russian Federation.
(c) Methodical recommendations on carrying out the primary inventory taking of radioactive materials and waste in the State accounting and control system.
(d) Forms for the federal State statistical review and instructions for their use: “Information about the presence, production, receipt and transfer of

radioactive materials and radioactive sources"; "Information about radioactive waste, and release of radionuclides into the environment".

(e) Forms for the presentation of operative information on the accounting and control of radioactive materials and waste to State systems: "Information about the transfer, receipt and sending for disposal of sealed radioactive sources and equipment containing such sources"; "Information about the transfer, receipt, writing-off and sending for disposal of open radioactive sources"; "Information about the transfer and disposal of radioactive waste"; "Information about the transfer, receipt and transfer to storage or reprocessing of spent nuclear fuel".

Three information flows occur within the framework of the system:

(i) Operative – when information on the production, movement, treatment and other operations with the source is entered into the system within ten days after the undertaking of the operations;
(ii) Statistical — connected with the collection and processing of statistical information about the activity of enterprises handling radioactive sources during one calendar year;
(iii) Periodic — connected with the inventory of sources of ionizing radiation.

When a new region is included in the system, an initial inventory of radioactive materials and waste must be completed by the organizations located on its territory. During the inventory taking, the physical presence and the main parameters of the sources of ionizing radiation are registered. Further control of the sources is carried out within the framework of operative reports of the organizations.

The Russian Gosatomnadzor is entrusted with the control of the system; it also controls maintenance of the established standards for handling radioactive sources.

The development of the system of State accounting and control of radioactive material (RM) and radioactive waste (RW) must be carried out in the following main directions:

Improvement of the legal basis for the control and management of RM and RW

At present, existing normative documents only regulate basic procedures for accounting of RM and RW. The development and endorsement of federal standards and rules on accounting and control of radioactive materials and radioactive waste, including physical control of sources at user and storage facilities, is an important task.

Methodical and metrological support of control functions

In order to provide measurements with the required accuracy, it is necessary to carry out scientific investigations, and design and development of instruments and methods for checking the main parameters of RM and RW.

Development of systems for transfer, storing and treatment of information

It is necessary to establish an operational communication system between the central information-analytical centre and the organizations manufacturing, using, storing and disposing of RM and RW.

Development of methods and facilities for simulating, analysing and forecasting any changes in the storage conditions of RM and RW

The purpose of these is to create an information base which can be used for taking economically and ecologically based decisions on the design, development (modernization) of production, reconstruction or closure (preservation) of locations for keeping RM and RW, rehabilitation of contaminated territories, etc. The interaction of organizations will make it possible to organize the cross-verification of information, and to make a comprehensive assessment of the ecological situation in the regions where the organizations are located.

Supplying organs of executive authorities at all levels with analytical information on the number and condition of facilities using and disposing of RM and RW, forecasts of the development of situations relating to the production, use, treatment, storage and disposal of RM and RW

To achieve the above mentioned purpose it is necessary to improve mechanisms for information exchange on both legal and technical levels.

Establishment of principles for international co-operation, adjustment of the relationships and data exchange with international organizations carrying out accounting and control of RM and RW

Here it is necessary to ensure continuity of the control of RM and RW and so ensure the prevention of losses and illegal export/import of RM.

At present, the priority tasks in the development of the system for State nuclear material and radioactive waste accounting and control are:

— Improvement of the normative base, regulation of the operation of the system for prevention of non-authorized use of sources of ionizing radiation;
— Establishment of regional information-analytical centres;
— Equipping of new centres and modernization of the hardware and software of existing centres;
— Improvement of storage facilities that do not meet modern physical protection requirements and development of the measures necessary for solution of the problems;
— Improvement of the skills of personnel responsible for realization of the accounting and control functions;
— Organization of the operative interaction between Minatom and the State Customs Committee, Gosatomnadzor and Gossanepidnadzor on problems relating to the accounting and control of radioactive sources.

Development and improvement of the system for State accounting and control of radioactive materials and radioactive waste in the Russian Federation will strengthen ecological safety and prevent the use of sources of ionizing radiation for criminal purposes.

The system should become an element in the international system of radioactive source control.

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M. SPAK	Editor

LIST OF PARTICIPANTS

ALBANIA

Bendo, G.	Permanent Mission of the Republic of Albania to the International Atomic Energy Agency, An den Langen Luessen 1/6/1, A-1190 Vienna, AUSTRIA Fax: +4313288711
Dylgjeri, Y.	Ministry of Public Order, Scanderbeg Square 33, Tirana, ALBANIA Fax: +3554253097
Kurtezi, R.	Permanent Mission of the Republic of Albania to the International Atomic Energy Agency, An den Langen Luessen 1/6/1, A-1190 Vienna, AUSTRIA Fax: +4313288711
Respishti, S.	Department of the United Nations and International Organizations, Ministry of Foreign Affairs, Boulevard Gjergj Fishta 6, Tirana, ALBANIA Fax: +3554362084 or 85 E-mail: repishti@xs4all.soras.al
Xhani, M.	Ministry of Health, Boulevard Bajram Curri 1, Tirana, ALBANIA Fax: +3554362554 E-mail: minister@moh.gov.al

Ylli, F. | Institute of Nuclear Physics,
P.O. Box 85,
Tirana,
ALBANIA
Fax: +3554362596
E-mail: inp@albaniaonline.net

ALGERIA

Benaboura, El-H. | Ministère de l'énergie et des mines,
80, avenue Gheumail,
Alger,
ALGERIA
Fax: +21321663136

Khelifi, S. | Permanent Mission of Algeria to the International Atomic Energy Agency,
Rudolfinergasse 18,
A-1190 Vienna,
AUSTRIA
Fax: +4313698856
E-mail: Said_Khelifi@yahoo.fr

Laboudi, A. | Centre de recherche nucléaire de Birine,
Commissariat à l'énergie atomique (COMENA),
B.P. 180,
17200 Ain Oussera, W. Djelfa,
ALGERIA
Fax: +21327872952
E-mail: crnb@wissal.dz

Zerguine, H. | Société nationale 'Sonatrach' Sidi Arcine,
B.P. 8,
Baraki, Alger,
ALGERIA
Fax: +21321675794

ARGENTINA

Clein, D.A. | Autoridad Regulatoria Nuclear (ARN),
Avenida del Libertador 8250,
1429 Buenos Aires,
ARGENTINA
Fax: +541163231771
E-mail: dclein@sede.arn.gov.ar

Oliveira, A.	Autoridad Regulatoria Nuclear (ARN), Avenida del Libertador 8250, 1429 Buenos Aires, ARGENTINA Fax: +541163231771/1798 E-mail: aoliveir@sede.arn.gov.ar
Peláez, H.R.	Permanent Mission of Argentina to the International Atomic Energy Agency, Goldschmiedgasse 2/1, A-1010 Vienna, AUSTRIA Fax: +4315338797
Spano, F.	Autoridad Regulatoria Nuclear (ARN), Avenida del Libertador 8250, 1429 Buenos Aires, ARGENTINA Fax: +541163231771 E-mail: fspano@sede.arn.gov.ar

ARMENIA

Asaturian, V.M.	Permanent Mission of Armenia to the International Atomic Energy Agency, Neubaugasse 12–14/1/16, A-1070 Vienna, AUSTRIA Fax: +4315227481 E-mail: asaturian@azmembassy.at
Harutyunyan, L.	Armenian Nuclear Regulatory Authority (ANRA), 4 Tigran Mets Street, 37510 Yerevan, ARMENIA Fax: +3741537978 E-mail: l.harutyunyan@anra.am
Nersesyan, V.	Armenian Nuclear Regulatory Authority (ANRA), 4 Tigran Mets Street, 37510 Yerevan, ARMENIA Fax: +3741543997/581962 E-mail: v.nerseyan@anra.am

AUSTRALIA

Loy, J.	Australian Radiation Protection and Nuclear Safety Agency, P.O. Box 655, Miranda, NSW 1490, AUSTRALIA Fax: +61295458314 E-mail: john.loy@health.gov.au
McIntosh, S.	Australian Nuclear Science and Technology Organisation (ANSTO), PMB 1, Menai, NSW 2234, AUSTRALIA Fax: +61295431452 E-mail: smi@ansto.gov.au
Tuniz, C.	Australian Nuclear Science and Technology Organisation (ANSTO), c/o Australian Embassy, Mattiellistrasse 2–4, A-1040 Vienna, AUSTRIA Fax: +4315041178 E-mail: claudio.tuniz@dfat.gov.au

AUSTRIA

Beck, P.	Österreichisches Forschungszentrum Seibersdorf, A-2444 Seibersdorf, AUSTRIA Fax: +4322547802502 E-mail: peter.beck@arcs.ac.at
Beno, J.	MBA Management, Gschwendt 34, A-3400 Klosterneuburg, AUSTRIA Fax: +43224326972 E-mail: gjb@attglobal.net
Berenda, W.	Federal Ministry of the Interior, Herrengasse 7, A-1010 Vienna, AUSTRIA Fax: +4312483685890 E-mail: willibald.berenda@bmi.gv.at

Beyerknecht, R.	Amt der Niederösterreichischen Landesregierung, Landhausplatz 1, A-3109 St. Pölten, AUSTRIA Fax: +431900514985 E-mail: roman.beyerknecht@noel.gv.at
Blach, W.	Federal Ministry of the Interior, Herrengasse 7, A-1010 Vienna, AUSTRIA Fax: +4312483685890 E-mail: wolfgang.blach@bmi.gv.at
Ditto, M.	Bundesanstalt für Lebensmitteluntersuchung und –forschung, Radetzkystrasse 2, A-1031 Vienna, AUSTRIA E-mail: manfred.ditto@bmsg.gv.at
Duftschmid, K.E.	Institute for Technical Physics, Technical University Graz, Petersgasse 16, A-8010 Graz, AUSTRIA Fax: +431225262468 E-mail: k.duftschmid@aon.at
Fehringer, W.	Federal Ministry of the Interior, Department II/5, Civil Protection School, Herrengasse 7, A-1014 Vienna, AUSTRIA Fax: +43225220308109 E-mail: wolfgang.fehringer@bmi.gv.at
Ferrero-Waldner, B.	Federal Ministry for Foreign Affairs, Ballhausplatz 2, A-1010 Vienna, AUSTRIA

Görz, W.	Austrian Research Centers GmbH (ARC), A-2444 Seibersdorf, AUSTRIA Fax: +43505503206 E-mail: walter.görz@arcs.ac.at
Göstl, C.	Federal Ministry for Economy and Labour, Landstrasser Hauptstrasse 55–57, A-1031 Vienna, AUSTRIA Fax: +431711008299
Hillebrand, G.	Austrian Research Centers GmbH (ARC), A-2444 Seibersdorf, AUSTRIA Fax: +43505502044 E-mail: guenter.hillebrand@arcs.ac.at
Hofer, P.	Federal Ministry of Agriculture, Forestry, Environment and Water Management, Radetzkystrasse 2, A-1031 Vienna, AUSTRIA Fax: +4317122331 E-mail: peter.hofer@bmlfuw.gv.at
Hohenberg, J.-K.	Federal Ministry of Agriculture, Forestry, Environment and Water Management, Radetzkystrasse 2, A-1031 Vienna, AUSTRIA Fax: +4317122331 E-mail: johann-klaus.hohenberg@hullfuw.gv.at
Karacson, P.	Amt der Niederösterreichischen Landesregierung, Landhausplatz 1, A-3109 St. Pölten, AUSTRIA Fax: +43190054289 E-mail: paul.karacson@noel.gv.at

Lampl, S.	NBC Defence School, Leobendorferstrasse 50, A-2100 Korneuburg, AUSTRIA Fax: +4312262727831721 E-mail: abcabw01@bmlv.gv.at
Lebeda, K.	Federal Ministry for Economy and Labour, Landstrasser Hauptstrasse 55–57, A-1031 Vienna, AUSTRIA Fax: +431711008299
Lechner, C.	Austrian Research Centers GmbH (ARC), A-2444 Seibersdorf, AUSTRIA Fax: +43505502603 E-mail: christian.lechner@arcs.ac.at
Lexa, D.	Austrian Research Centers GmbH (ARC), A-2444 Seibersdorf, AUSTRIA Fax: +43505502603 E-mail: dusan.lexa@arcs.ac.at
Musilek, A.	Atominstitut der Österreichischen Universitäten, Stadionallee 2, A-1020 Vienna, AUSTRIA Fax: +4315880114199 E-mail: amusilek@ati.ac.at
Rams, O.H.R.	AG Körner, Hütteldorferstrasse 126, A-1140 Vienna, AUSTRIA E-mail: orams@hotmail.com
Schmidt, F.-W.	Federal Ministry for Economy and Labour, Landstrasser Hauptstrasse 55–57, A-1031 Vienna Fax: +431711008299 E-mail: fritz.schmidt@bmwa.gv.at

Schmitzer, C.
Austrian Research Centers GmbH (ARC),
A-2444 Seibersdorf,
AUSTRIA
Fax: +43055502502
E-mail: chris.schmitzer@arcs.ac.at

Steinhäusler, F.
University of Salzburg,
Hellbrunnerstrasse 34,
A-5020 Salzburg,
AUSTRIA
Fax: +436628044150
E-mail: physik@sbg.ac.at

Stelzer, T.
Permanent Mission of Austria to the International Atomic Energy Agency,
Andromeda Tower, 11th Floor,
Donau-City-Strasse 6,
A-1220 Vienna,
AUSTRIA
Fax: +4312637281

Steyer, C.
Preng and Associates,
Nussdorfer Strasse 38,
A-1090 Vienna,
AUSTRIA
Fax: +4313100348
E-mail: csteyer@preng.com

Tauber, J.
Austrian Research Centers GmbH (ARC),
A-2444 Seibersdorf,
AUSTRIA
Fax: +435055032603
E-mail: josef.tauber@arcs.ac.at

Timal, G.
Federal Ministry of the Interior,
Akademiestrasse 3,
A-2514 Traiskirchen,
AUSTRIA
Fax: +43225220308109
E-mail: guenter.timal@bmi.gv.at or

Weimann, G.H.	Austrian Research Centers GmbH (ARC), Kramergasse 1, A-1010 Vienna, AUSTRIA Fax: +43505503206 E-mail: geert.weimann@arcs.ac.at
Wilson, K.G.	Paul C. Rizzo Associates, GmbH, Neustift am Walde 89, A-1190 Vienna, AUSTRIA Fax: +431447980 E-mail: kevingwilson@aol.com
Zatolokine, B.	MEET Zatolokina OEG, Tamariskengasse 102/13/5, A-1220 Vienna, AUSTRIA Fax: +4312836429 E-mail: mateval@mateval.com
Zechner, J.E.	Bundesministerium für Gesundheit und Konsumentenschutz, Radetzkystrasse 2, A-1030 Vienna, AUSTRIA
Ziegler, E.	Cabinet of the Federal Ministry for Foreign Affairs, Abteilung II 8a, Minoritenplatz 5, A-1010 Vienna, AUSTRIA
Zischg, R.	Federal Ministry for Foreign Affairs, Ballhausplatz 2, A-1014 Vienna, AUSTRIA E-mail: robert.zischg@bmaa.gov.at

AZERBAIJAN

Huseynov, A.
Integrated Plant with Special Assignment 'Izotop',
Javadkhan Street 15A,
370102 Baku,
AZERBAIJAN
Fax: +99412310893
E-mail: az@cifal.in-baku.com

Muradov, G.
Ministry of Foreign Affairs of the Republic of Azerbaijan,
Sh. Guebanov Street 4,
370009 Baku,
AZERBAIJAN
Fax: +99412925565
E-mail: tpi@mta.gov.az

Sadiqov, V.
Permanent Mission of the Republic of Azerbaijan to the International Atomic Energy Agency,
Hügelgasse 2,
A-1130 Vienna,
AUSTRIA
Fax: +4314031323
E-mail: office@azembvienna.at

Shahbazov, P.
Permanent Mission of the Republic of Azerbaijan to the International Atomic Energy Agency,
Hügelgasse 2,
A-1130 Vienna,
AUSTRIA
Fax: +4314031323
E-mail: office@azembvienna.at

BANGLADESH

Hassan, K.M.
Ministry of Science and Information and Communication Technology,
Bhaban 6, Dhaka 1000,
BANGLADESH
Fax: +88028619606
E-mail: most@bangla.net

Karim, C.S.	Bangladesh Atomic Energy Commission, 4 Kazi Nazrul Islam Avenue, P.O. Box 158, Ramna Dhaka 1000, BANGLADESH Fax: +88028613051 E-mail: nped@citechco.net

BELARUS

Avin, I.	State Customs Committee of the Republic of Belarus, 11, Kamunistychnaya Street, 220029 Minsk, BELARUS Fax: +375172349596
Gaisenak, V.	Permanent Mission of the Republic of Belarus to the International Atomic Energy Agency, Hüttelbergstrasse 6, A-1140 Vienna, AUSTRIA Fax: +431419963030 E-mail: amb@byembassy.at
Kagan, L.	JV Polimaster Ltd, 112, Bogdanovich Street, 220040 Minsk, BELARUS Fax: +375172177081 E-mail: kagan@polimaster.com
Kupchyna, A.	Department of Humanitarian, Ecological and Scientific Co-operation, Ministry of Foreign Affairs of the Republic of Belarus, 19, Lenin Street, 220004 Minsk, BELARUS Fax: +375172274521
Mishkorudny, I.	Permanent Mission of the Republic of Belarus to the International Atomic Energy Agency, Hüttelbergstrasse 6, A-1140 Vienna, AUSTRIA Fax: +431419963030

Novikov, G.F.
Department for Emergency Preparedness and Civil Defense,
Ministry for Emergencies,
5, Revolutsionnaya Street,
220050 Minsk,
BELARUS
Fax: +37517205191
E-mail: mcs@infonet.by or larisasar@open.by

Stavrov, A.
International Ecological University,
23, Dolgobrodskaja Street,
220009 Minsk,
BELARUS
Fax: +375172319927
E-mail: stavrov1@narod.ru

Sychov, A.N.
Ministry of Foreign Affairs of the Republic of Belarus,
19, Lenin Street,
220030 Minsk,
BELARUS
Fax: +37517224259
E-mail: ugs@mfa.org.by

Zdorov, D.
Permanent Mission of the Republic of Belarus to the International Atomic Energy Agency,
Hüttelbergstrasse 6,
A-1140 Vienna,
AUSTRIA
Fax: +431419963030
E-mail: unmission@byembassy.at

BELGIUM

de Sloover, J.C.
Administration of Customs and Excise,
I.P.S. L.O. Douane,
Quatre Brasstraat 13/1,
B-1000 Brussels,
BELGIUM
Fax: +3225087022
E-mail: jos.AP@mibz-fgov.be

Deboodt, P. | SCK-CEN, Belgian Nuclear Research Centre,
Boeretang 200,
B-2400 Mol,
BELGIUM
Fax: +3214321624
E-mail: pdeboodt@sckcen.be

Di Leone, N. | Agence fédérale de contrôle nucléaire (AFCN),
Rue Ravenstein 36,
B-1000 Brussels,
BELGIUM
Fax: +3222892106
E-mail: norma.dileone@fanc.fgov.be

Janssens de Bistoven, J.-C. | Permanent Mission of Belgium to the
International Atomic Energy Agency,
Wohllebengasse 6,
A-1040 Vienna,
AUSTRIA
Fax: +4315020711
E-mail: ambabel.vienna@magnet.at

Sohier, A.F.P.M. | SCK-CEN, Belgian Nuclear Research Centre,
Boeretang 200,
B-2400 Mol,
BELGIUM
Fax: +3214321056
E-mail: asohier@sckcen.be

BENIN

Akala, Y. A. | Ministry of Environment, Housing and Land Planning,
01-B.P. 3621,
Cotonou,
BENIN
Fax: +229315081
E-mail: p.focalben@firstnet.bj

BOLIVIA

Carrasco Monje, M. | Permanent Mission of Bolivia to
the International Atomic Energy Agency,
Waaggasse 10/4,
A-1040 Vienna,
AUSTRIA
Fax: +4315866880
E-mail: carrascomonje@hotmail.com

Miranda Cuadros, A.A.	Instituto Boliviano de Ciencia y Tecnología Nuclear (IBTEN), Avenida 6 de Agosto 2905, Casilla Postal 4821, La Paz, BOLIVIA Fax: +59122433063 E-mail: ibten@caoba.entelnet.bo
Olmos, S.	Permanent Mission of Bolivia to the International Atomic Energy Agency, Waaggasse 10/4, A-1040 Vienna, AUSTRIA Fax: +4315866880 E-mail: embol.austria@chello.at

BOSNIA AND HERZEGOVINA

Glavocevic, L.	Federation Ministry of Internal Affairs, Mehmeda Spahe 7, 71000 Sarajevo, BOSNIA Fax: +38733466530 E-mail: gljuban@hotmail.com

BOTSWANA

Motlhanka, K.F.	Botswana Police, P.O. Box 1082, Gaborone, BOTSWANA Fax: +2673973723 E-mail: fmothlanka@gov.bw or fmothlanka@hotmail.com

BRAZIL

Abdenur, R.	Permanent Mission of Brazil to the International Atomic Energy Agency, Lugeck 1/V/15, A-1010 Vienna, AUSTRIA Fax: +4315138374

dos Santos, R. — Institute of Radiation Protection and Dosimetry,
Av. Salvador Allende s/n,
Recreio dos Bandeirantes,
BR-22780-160 Rio de Janeiro RJ,
BRAZIL
Fax: +552124422548
E-mail: raul@ird.gov.br

Suzuki, F.F. — Instituto de Pesquisas Energéticas e Nucleares,
IPEN/CNEN,
Av. Prof. Lineu Prestes 2242,
Cidade Universitaria,
BR-05508-000 São Paulo SP,
BRAZIL
Fax: +551138169221
E-mail: ffsuzuki@.ipen.br

Vinhas, L. — International Relations Office,
National Nuclear Energy Commission,
Rua General Severiano 90, Botafogo,
BR-22294-900 Rio de Janeiro RJ,
BRAZIL
Fax: +552125462213
E-mail: lavinhas@cnen.gov.br

BULGARIA

Vapirev, E.I. — Nuclear Regulatory Agency,
69 Shipchenski prokhod Boulevard,
BG-1574 Sofia,
BULGARIA
Fax: +35929406919
E-mail: evapirev@bnsa.bas.bg

CAMBODIA

Soeung Vandoeun — Department of Technique, Ministry of Industry,
45 B1 Norodom Boulevard,
Phnom Penh,
CAMBODIA
Fax: +85523428263
E-mail: deunsoeung@yahoo.com

CAMEROON

Essame, A.
Transmission Division,
General Delegation of National Security,
Yaounde,
CAMEROON
Fax: +2372208964

Nyobe, J.B.
Ministry of Scientific and Technical Research,
P.O. Box 1457,
Yaounde,
CAMEROON
Fax: +2372221336
E-mail: jbnyobe@yahoo.fr

Seme Nnang, J.-P.
Ministère des mines, de l'eau et de l'énergie,
S/C B.P. 8009,
Yaounde,
CAMEROON

CANADA

Bilodeau, A.K.A.J.
Department of Foreign Affairs
and International Trade,
125 Sussex Drive,
Ottawa, Ontario K1A 0G2,
CANADA
Fax: +16139441835
E-mail: alexandre.bilodeau@dfait-maeci.gc.ca

Dubé, J.B.J.P.
Canadian Nuclear Safety Commission,
P.O. Box 1046, Station B,
280 Slater Street,
Ottawa, Ontario K1P 5S9,
CANADA
Fax: +16139433085
E-mail: dubep@cnsc-ccsn.gc.ca

Gendron, I.V.
Canadian Nuclear Safety Commission,
P.O. Box 1046, Station B,
280 Slater Street,
Ottawa, Ontario K1P 5S9,
CANADA
Fax: +16139969694
E-mail: gendroni@cnsc-ccsn.gc.ca

Gray, B.	Permanent Mission of Canada to the International Atomic Energy Agency, Laurenzerberg 2, A-1010 Vienna, AUSTRIA Fax: +431531383321
Hall, I.	Permanent Mission of Canada to the International Atomic Energy Agency, Laurenzerberg 2, A-1010 Vienna, AUSTRIA Fax: +431531383321
Jammal, R.	Canadian Nuclear Safety Commission, P.O. Box 1046, Station B, 280 Slater Street, Ottawa, Ontario K1P 5S9, CANADA Fax: +6139955086 E-mail: jammalr@cnsc-ccsn.gc.ca
Kelly, D.	Department of Foreign Affairs and International Trade, 125 Sussex Drive, Ottawa, Ontario K1A 0G2, CANADA Fax: +16139441130 E-mail: diedrah.kelly@fait-maeci.gc.ca
Kupca, S.	National Defence Headquarters, MGen George R. Pearkes Building, Ottawa, Ontario K1A 0K2, CANADA Fax: +16139925537 E-mail: kupca.s@forces.gc.ca
Martell, E.S.	MDS Nordion, 447 March Road, Ottawa, Ontario K2K 1X8, CANADA Fax: +16135922006 E-mail: emartell@mds.nordion.com

Proudfoot, S. Permanent Mission of Canada to the
International Atomic Energy Agency,
Laurenzerberg 2,
A-1010 Vienna,
AUSTRIA
Fax: +431531383321

Viglasky, T.P. Directorate of Nuclear Substance Regulation,
Canadian Nuclear Safety Commission,
P.O. Box 1046, Station B,
Ottawa, Ontario K1P 5S9,
CANADA
Fax: +16139473993
E-mail: viglaskyt@cnsc-ccsn.gc.ca

Wood, T.S. Department of Foreign Affairs
and International Trade,
125 Sussex Drive,
Ottawa, Ontario K1A 0G2,
CANADA
Fax: +16139440035
E-mail: terry.wood@dfait-maeci.gc.ca

CHILE

González Aninat, R. Permanent Mission of the Republic of Chile
to the International Atomic Energy Agency,
Lugeck 1/III/10,
A-1010 Vienna,
AUSTRIA
Fax: +431512920833

Riesle, J.E. Chile Nuclear Energy Commission,
Amunátegui 95,
Casilla 188-D,
Santiago,
CHILE
Fax: +5623646263
E-mail: jriesle@gopher.cchen.cl

Tenreiro, C.
Chile Nuclear Energy Commission,
Amunátegui 95,
Casilla 188-D,
Santiago,
CHILE
Fax: +5626990735
E-mail: ctenreiro@gopher.cchen.cl

Torres, G.
Permanent Mission of the Republic of Chile to the International Atomic Energy Agency,
Lugeck 1/III/10,
A-1010 Vienna,
AUSTRIA
Fax: +431512920833
E-mail: gtorres@eunet.at

CHINA

Cao, Shudong
Permanent Mission of China to the International Atomic Energy Agency,
Steinfeldgasse 3,
A-1190 Vienna,
AUSTRIA
Fax: +4313706626
E-mail: atom2.pmchina@eunet.at

Cheng, Jian
China Atomic Energy Authority (CAEA),
8A, Fuchenglu,
Haidian District,
Beijing 100037,
CHINA
Fax: +861088581516
E-mail: caea@public.bta.net.cn

Dang, Xiao Hong
Department of Supervision and Control Customs,
Customs General Administration of China,
6, Jian Guo Men Nei Avenue,
Beijing 100730,
CHINA
Fax: +861065195356
E-mail: dang-xh@mail.customs.gov

Fang, Xianbo	Permanent Mission of China to the International Atomic Energy Agency, Steinfeldgasse 3, A-1190 Vienna, AUSTRIA Fax: +4313706626 E-mail: atom5.pmchina@eunet.at
Feng, Yi	China Atomic Energy Authority (CAEA), 8A, Fuchenglu, Haidian District, Beijing 100037, CHINA Fax: +861088581297 E-mail: xtesfy@caea.gov.cn
Hao, Xiaofeng	Permanent Mission of China to the International Atomic Energy Agency, Steinfeldgasse 3, A-1190 Vienna, AUSTRIA Fax: +4313706626 E-mail: atom7.pmchina@eunet.at
He, Qinghua	Department of Health Legislation and Inspection, Ministry of Health, South Road, Xizhimen Wai, Beijing 100044, CHINA Fax: +861068792400 E-mail: heqinghua@ibs.net
Jiang, Liyun	Office of Antiterrorism, Ministry of Public Security, 14, Dong Changanjie, Dongcheng District, Beijing 100741, CHINA
Li, Chijiang	Department of Arms Control, Ministry of Foreign Affairs, 2, Chaoyangmen Nandajie, Chaoyang District, Beijing 100701, CHINA

Li, Jungang	Ministry of Public Security 14, Dong Changanjie, Dongcheng District, Beijing 100741, CHINA Fax: +86106520 4302 E-mail: ljgmail1997@yahoo.com.cn
Li, Junjie	Permanent Mission of China to the International Atomic Energy Agency, Steinfeldgasse 3, A-1190 Vienna, AUSTRIA Fax: +4313706626 E-mail: atom4.pmchina@eunet.at
Li, Sen	China Atomic Energy Authority (CAEA), 8A, Fuchenglu, Haidian District, Beijing 100037, CHINA Fax: +861088581516 E-mail: caea@public.bta.net.cn
Ma, Hua	State Environment Protection Administration, 115, Xizhimennei Nan Xiaojie, Beijing 100035, CHINA Fax: +861066126715 E-mail: ma.hua@263.net
Ning, Chung Yong	News Center of China Atomic Energy Authority (CAEA), 8A, Fuchenglu, Haidian District, Beijing 100037, CHINA Fax: +861088581493 E-mail: ncr0537@sina.com
Xu, Yuming	China Atomic Energy Authority (CAEA), 2A, Guanganmen Najie, Xuanwu District, Beijing 100053, CHINA Fax: +861088583511

Yu, Zhuoping

Permanent Mission of China to the
International Atomic Energy Agency,
Steinfeldgasse 3,
A-1190 Vienna,
AUSTRIA
Fax: +4313706626
E-mail: atom3.pmchina@eunet.at

Zhang, Jin Tao

China National Nuclear Corporation,
P.O. Box 2102-14,
Beijing 100822,
CHINA
Fax: +861068539375
E-mail: zjt@cnnc.com.cn

Zhang, Jing

China Atomic Energy Authority (CAEA),
8A, Fuchenglu,
Haidian District,
Beijing 100037,
CHINA
Fax: +861088581516
E-mail: zhangjing@caea.gov.cn

Zhang, Yan

Permanent Mission of China to the
International Atomic Energy Agency,
Steinfeldgasse 3,
A-1190 Vienna,
AUSTRIA
Fax: +4313706626
E-mail: atom2.pmchina@eunet.at

COLOMBIA

Arevalo Yépes, C.

Permanent Mission of Colombia to the
International Atomic Energy Agency,
Stadiongasse 6–8,
A-1010 Vienna,
AUSTRIA
Fax: +4314088303
E-mail: embcolviena@aon.at

Samper, H.C. Permanent Mission of Colombia to the International Atomic Energy Agency,
Stadiongasse 6–8,
A-1010 Vienna,
AUSTRIA
Fax: +4314088303
E-mail: embcolviena@aon.at

COSTA RICA

López Cardenas, E. Ministry of Health,
Calle 14, Avenida 6 y 8,
San José,
COSTA RICA
Fax: +5062552594
E-mail: minsalud@netsalud.sa.cr

Pardo Evanz, R. Ministerio de Ciencias y Tecnología,
Apartado Postal 5589-1000,
San José,
COSTA RICA
Fax: 5062903343
E-mail: gdt@micit.go.cr

CÔTE D'IVOIRE

Coulibaly, M. Laboratoire national de la santé,
18 B.P. 2403,
Abidjan 18,
CÔTE D'IVOIRE
Fax: +22521350873
E-mail: lnspci@globeaccess.net

Kouame, Y. Laboratoire national de la santé,
18 B.P. 2403,
Abidjan 18,
CÔTE D'IVOIRE
Fax: +22521350873

CROATIA

Belamaric, N. Ministry of Health,
Ksaver 200a,
HR-10 000 Zagreb,
CROATIA
Fax: +38514607631
E-mail: nera.belamaric@miz.hr

Kvaternik, I.
Ministry of Interior,
Savska 39,
HR-10 000 Zagreb,
CROATIA
Fax: +38513788820
E-mail: ikvatern@inet.hr

Matek, V.
Permanent Mission of the Republic of Croatia to the International Atomic Energy Agency,
Bartensteingasse 16/7,
A-1010 Vienna,
AUSTRIA
Fax: +4315250134
E-mail: cromiss.vienna@mup.hr

Mikec, N.
Permanent Mission of the Republic of Croatia to the International Atomic Energy Agency,
Bartensteingasse 16/7,
A-1010 Vienna,
AUSTRIA
Fax: +4315350134
E-mail: cromiss.vienna@mup.hr

Nobilo, M.
Ministry of Foreign Affairs of the Republic of Croatia,
Trg. N.S. Zrinskog 7–8,
HR-10 000 Zagreb,
CROATIA
Fax: +38514569971
E-mail: un@mvp.hr

Nota, R.
Ministry of Economy,
Ulica grada Vukovara 78,
HR-10 000 Zagreb,
CROATIA
Fax: +38516109113
E-mail: roman.nota@mingo.hr

Subasic, D.
APO Hazardous Waste Management Agency,
Savska cesta 41/IV,
HR-10 000 Zagreb,
CROATIA
Fax: +38516176734
E-mail: damir.subasic@apo.tel.hr

Valcic, I. | Department of Nuclear Safety,
Ministry of Economy,
Ulica grada Vukovara 78,
HR-10 000 Zagreb,
CROATIA
Fax: +38516109113
E-mail: ivo.valcic1@mingo.hr

Vekic, B. | Ruder Boskovic Institute,
Bijenicka Cesta 54,
P.O. Box 180,
HR-10 000 Zagreb,
CROATIA
Fax: +38514680098
E-mail: bvekic@rudjer.irb.hr

CUBA

Betancourt Hernandez, L.A. | National Center of Nuclear Safety,
Calle 28, No. 504,
C.P. 11300,
Miramar,
La Habana,
CUBA
Fax: +532031664
E-mail: aniuska@cnsn.cu

Zerquera, J.T. | Center for Hygiene and Radiation Protection,
Calle 20, No. 4113 e/41 y 47,
C.P. 11300,
Playa,
La Habana,
CUBA
Fax: +537579573
E-mail: jtomas@cphr.edu.cu

CYPRUS

Demetriades, P. | Department of Labour Inspection,
Ministry of Labour and Social Insurance,
12 Apelli Street,
CY-1480 Nicosia,
CYPRUS
Fax: +35722663788
E-mail: roc.dli@cytanet.com.cy

Kyriakides, C. | Cyprus Civil Defence,
63 Pericleous,
P.O. Box 23830,
CY-1686 Nicosia,
CYPRUS
Fax: +35722315638
E-mail: ge.cd@cytanet.com.cy

CZECH REPUBLIC

Drábová, D. | State Office for Nuclear Safety (SUJB),
Senovázné námestí 9,
CZ-110 00 Prague 1,
CZECH REPUBLIC
Fax: +420221624704
E-mail: dana.drabova@subj.cz

Gorgol, O. | Ministry of Foreign Affairs,
Loretánské námestí 5,
CZ-118 00 Prague 1,
CZECH REPUBLIC
Fax: +420224182491
E-mail: ogorgol@centrum.cz

Hátle, Z. | Decomkov Praha Ltd,
Cukrovarnicka Street No. 57,
CZ-162 00 Prague 6,
CZECH REPUBLIC
Fax: 233343914
E-mail: decomkov@senior.cz

Kanka, F. | Police of the Czech Republic,
P.O. Box 41/V2,
CZ-156 00 Prague 5,
CZECH REPUBLIC
Fax: +420974842598
E-mail: osuooz@mvcr.cz

Klucky, P. | Permanent Mission of the Czech Republic
to the International Atomic Energy Agency,
Penzingerstrasse 11–13,
A-1140 Vienna,
AUSTRIA
Fax: +4318945798
E-mail: mission.vienna@embassy.mzv.cz

Kucerka, M. Radioactive Waste Repository Authority,
Dlazdena 6,
CZ-110 00 Prague,
CZECH REPUBLIC
Fax: +420221421544
E-mail: kucerka@rawra.cz

Masek, K. Ministry of Finance,
General Directorate of Customs,
Budejovicka 7,
CZ-140 96 Prague 4,
CZECH REPUBLIC
Fax: +420261332220
E-mail: k.masek@cs.mfcr.cz

Prouza, Z. State Office for Nuclear Safety (SUJB),
Senovázné námestí 9,
CZ-110 00 Prague 1,
CZECH REPUBLIC
Fax: +420221624710
E-mail: zdenek.prouza@sujb.cz

Stehno, L. Police of the Czech Republic,
P.O. Box 41/V2,
CZ-156 80 Prague 5, Zbraslav,
CZECH REPUBLIC
Fax: +420974842596
E-mail: osuooz@mvcr.cz

Vacek, P. Permanent Mission of the Czech Republic
to the International Atomic Energy Agency,
Penzingerstrasse 11–13,
A-1140 Vienna,
AUSTRIA
Fax: +4318945798
E-mail: mission.vienna@embassy.mzv.cz

DEMOCRATIC REPUBLIC OF THE CONGO

Lumu Badimbayi-Matu, F. Commissariat général à l'énergie atomique,
CGEA/CRENK,
P.O. Box 868,
Kinshasa XI,
DEMOCRATIC REPUBLIC OF THE CONGO
Fax: +2438801205
E-mail: cgeacrenk@yahoo.fr

Tshibambe Ndjibu, Z.	Office des douanes et accises (OFIDA), Kinshasa Gombe, DEMOCRATIC REPUBLIC OF THE CONGO Fax: +2431234060 E-mail: ztshibambe@yahoo.fr

DENMARK

Ulbak, K.	National Institute of Radiation Hygiene, Knapholm 7, DK-2730 Herlev, DENMARK Fax: +4544543450 E-mail: ku.@sis.dk

DOMINICAN REPUBLIC

Sbriz Zeitun, L.	Comisión Nacional de Asuntos Nucleares (CNAN), Colonel Fernandez Domínguez 30A, Edificio Carol, Apto. 102, Ensanche la Fé, 30333 Santo Domingo, DOMINICAN REPUBLIC Fax: +18095497609 E-mail: l_sbriz@hotmail.com or
Valconi, G.	Centro Nacional de Protección Radiologica, Comisión Nacional de Asuntos Nucleares (CNAN), Colonel Fernandez Domínguez 30A, Ensanche la Fé, 30333 Santo Domingo, DOMINICAN REPUBLIC Fax: +18096832072 E-mail: gino.valconi@codetel.net.do

ECUADOR

Moreno, S.	Ecuadorian Atomic Energy Commission, Juan Larrea 534 y Ríofrío, P.O. Box 17-01-2517, Quito, ECUADOR Fax: +59322563336 E-mail: comecen1@comecenat.gov.ec

Salgado Campana, D.C. Permanent Mission of Ecuador to the
International Atomic Energy Agency,
Goldschmiedgasse10/II/24,
A-1010 Vienna,
AUSTRIA
Fax: +4315350897

Sosa, J. National Police of Ecuador,
Juan L. Mera y V.R. Roca,
Quito,
ECUADOR
Fax: +59322503945
E-mail: jfsosabarreno@hotmail.com

EGYPT

Gaber, F.A. National Centre for Nuclear Safety
and Radiation Control,
Atomic Energy Authority,
3 Ahmed El-Zomor Street, 8th Sector,
P.O. Box 7551,
Nasr City 11762, Cairo,
EGYPT
Fax: +2022740238
E-mail: famagied@hotmail.com

Youssef, O. Permanent Mission of Egypt to the
International Atomic Energy Agency,
Hohe Warte 52,
A-1190 Vienna,
AUSTRIA
Fax: +431370810427
E-mail: omaryoussef@hotmail.com

EL SALVADOR

Betancourt, H.A. Ministry of Health,
Residencial Jardines de la Libertad,
Calle Tepecoyo 26-E,
Ciudad Merliot,
San Salvador,
EL SALVADOR
Fax: +5032210985
E-mail: hbetancourt@mspas.gob.sv

Bolaños Carballo, V.M. Fuerza Armada de El Salvador,
EMCFA, km 5½,
Carretera a Santa Tecla,
San Salvador,
EL SALVADOR
Fax: +5032230875
E-mail: victor.bolaños.2003@yahoo.com.mx

ESTONIA

Kass, N. Estonian Customs Board,
Lõkke 5,
EE-15175 Tallinn,
ESTONIA
Fax: +3726967773
E-mail: Neeme.Kass@customs.ee

Schmalz, M. Security Police Board,
Toompuiestee 3,
EE-10142 Tallinn,
ESTONIA
Fax: +3726121401
E-mail: kapo@kapo.ee

ETHIOPIA

Gebeyehu Wolde, G. National Radiation Protection Authority (NRPA),
P.O. Box 20486, Code 1000,
Addis Ababa,
ETHIOPIA
Fax: +2511620495
E-mail: nrpa@telecom.net.et

Mohammed, H. Permanent Mission of Ethiopia to
the International Atomic Energy Agency,
Zaunergasse 1–3/1/H1,
A-1030 Vienna,
AUSTRIA
Fax: +4317102171
E-mail: ethiopia@eunet.at

Wolde, L.A. Permanent Mission of Ethiopia to
the International Atomic Energy Agency,
Zaunergasse 1–3/1/H1,
A-1030 Vienna,
AUSTRIA
Fax: +4317102171

Wollel, G. National Radiation Protection Authority (NRPA),
P.O. Box 20486, Code 1000,
Addis Ababa,
ETHIOPIA
Fax: +2511620495
E-mail: nrpa@telecom.net.et

FINLAND

Kemppainen, A. Permanent Mission of Finland to
the International Atomic Energy Agency,
Gonzagagasse 16,
A-1010 Vienna,
AUSTRIA
Fax: +4315355703
E-mail: anne.kemppainen@formin.fi

Kettunen, E.V.S. Radiation and Nuclear Safety Authority (STUK),
P.O. Box 14,
FIN-00881 Helsinki,
FINLAND
Fax: +358975988248
E-mail: eero.kettunen@stuk.fi

Mutru, M. Permanent Mission of Finland to
the International Atomic Energy Agency,
Gonzagagasse 16,
A-1010 Vienna,
AUSTRIA
Fax: +4315355703

Oksanen, E.U.I. Radiation and Nuclear Safety Authority (STUK),
P.O. Box 14,
FIN-00881 Helsinki,
FINLAND
Fax: +358975988248
E-mail: eero.oksanen@stuk.fi

FRANCE

Albert, M.G.	Direction des relations internationales, CEA/DRI, 31–33, rue de la Fédération, F-75752 Paris Cedex 15, FRANCE Fax: +33142730151 E-mail: marc-gerard.albert@cea.fr
Brochard, D.	Institut de radioprotection et de sûreté nucléaire (IRSN), DSMR/SATE, B.P. 17, F-92262 Fontenay-aux-Roses Cedex, FRANCE Fax: +33142535100 E-mail: didier.brochard@irsn.fr
Camus, H.B.	Ministry of Defence (Strategic Affairs), 14, rue Saint-Dominique, F-00450 Armées, FRANCE Fax: +33142194011 E-mail: henri.camus@defense.gouv.fr
Champion, D.	Institut de radioprotection et de sûreté nucleaire, IRSN/DPHD/SEGR/SAER, B.P. 17, F-92262 Fontenay-aux-Roses Cedex, FRANCE Fax: +33146544610 E-mail: didier.champion@irsn.fr
Dallendre, R.	Institut de radioprotection et de sûreté nucléaire (IRSN), B.P. 17, F-92262 Fontenay-aux-Roses Cedex, FRANCE Fax: +33158358509 E-mail: robert.dallendre@irsn.fr

de Longevialle, H.	Ministry of Foreign Affairs, 37, Quai d'Orsay, F-75007 Paris, FRANCE Fax: +33143175410 E-mail: hugues.de-longevialle@diplomatie.gouv.fr
Delmas-Marsalet, B.	Commissariat à l'énergie atomique (CEA), B.P. 6, F-92265 Fontenay-aux-Roses, FRANCE Fax: +33146549432 E-mail: bertrand.delmas-marsalet@cea.fr
Feron, F.B.G.	Direction générale de la sûreté nucléaire et de la radioprotection (DGSNR), 10, route du Panorama, F-92266 Fontany-aux-Roses Cedex, FRANCE Fax: +33143197140 E-mail: fabien.feron@asn.minefi.gouv.fr
Fracas, P.	DCS/SHSP, Commissariat à l'énergie atomique, B.P. 6, F-92265 Fontenay-aux-Roses Cedex, FRANCE Fax: +331465448178 E-mail: patrick.fracas@cea.fr
Gravier, S.	Secrétariat général du comité interministériel de la sécurité nucléaire, 13, rue de Bourgogne, F-75007 Paris, FRANCE Fax: +33142757605 E-mail: s.gravier@cisn.pm.gouv.fr
Guyonnet, R.	Secrétariat général de la défense nationale, 51, Bd. Latour-Maubourg, F-75007 Paris, FRANCE Fax: +33171758060 E-mail: regis.guyonnet@sgdn.pm.gouv.fr

Lacoste, A.-C.

Direction générale de la sûreté nucléaire
et de la radioprotection (DGSNR),
6, Place du Colonel Bourgoin,
F-75572 Paris Cedex 12,
FRANCE
Fax: +33143198624
E-mail: andre-claude.lacoste@asn.minefi.gouv.fr

Lecomte, J.-F.

Institut de radioprotection et de sûreté nucléaire
(IRSN),
B.P. 17,
F-92262 Fontenay-aux-Roses,
FRANCE
Fax: +33158357962
E-mail: jean-francois.lecomte@irsn.fr

Louvat, D.

Institut de radioprotection et de sûreté nucléaire
(IRSN),
Cadarache, Batîment 153,
B.P. 3,
F-13115 Saint-Paul-lez-Durance,
FRANCE
Fax: +33442256373
E-mail: didier.louvat@irsn.fr

Mechineau, B.

Permanent Mission of France to the
International Atomic Energy Agency,
Schwarzenbergplatz 16,
A-1010 Vienna,
AUSTRIA
Fax: +43150182329
E-mail: del.fra.onu@france.jet2web.at

Moreau, J.-F.

Saphymo,
5, rue du Théatre,
F-91884 Massy,
FRANCE
Fax: +33169537301
E-mail: jfmoreau@saphymo.fr

Mourlon, J.C. Permanent Mission of France to the
International Atomic Energy Agency,
Schwarzenbergplatz 16,
A-1010 Vienna,
AUSTRIA
Fax: +43150182329
E-mail: jean-claude.mourlon@diplomatie.fr

Pizzo, M.E. DGA/DSP/CAD,
16 bis, avenue Prieur de la Côte d'Or,
F-94114 Arcueil,
FRANCE
Fax: +33142919175
E-mail: emmanuel.pizzo@cad.etw.fr

Plaisant, E. Service du haut fonctionnaire de défense,
Ministère de l'économie, des finances et de l'industrie,
20, avenue de Ségur,
F-75353 Paris 07 SP,
FRANCE
Fax: +33143195061
E-mail: eric.plaisant@hfd.finances.gouv.fr

Pujol, E. Permanent Mission of France to the
International Atomic Energy Agency,
Schwarzenbergplatz 16,
A-1010 Vienna,
AUSTRIA
Fax: +43150182329
E-mail: eric.pujol@diplomatie.fr

Rousseau, D. Permanent Mission of France to the
International Atomic Energy Agency,
Schwarzenbergplatz 16,
A-1010 Vienna,
AUSTRIA
Fax: +43150182329
E-mail: del.fra.onu@france.jet2web.at

GEORGIA

Dzagnidze, S.

Anti-Terror Center,
Ministry of Security,
Vaja Pshavela Avenue 72,
Tbilisi,
GEORGIA
Fax: +99532333952
E-mail: brus@access.sanet.ge

Gheghechkori, A.

Permanent Mission of Georgia to
the International Atomic Energy Agency,
Doblhoffgasse 5/5,
A-1010 Vienna,
AUSTRIA
Fax: +431403984820
E-mail: tato_ghe@hotmail.com

Kakushadze, S.

Nuclear Radiation Safety Service,
Paliashvili Street 87,
380062 Tbilisi,
GEORGIA
Fax: +99532332867
E-mail: brus@access.sanet.ge

GERMANY

Bühling, F.A.

Federal Ministry of Environment, Nature
Conservation and Nuclear Safety,
P.O. Box 120629,
D-53048 Bonn,
GERMANY
Fax: +49188823052828
E-mail: andreas.buehling@bmu.bund.de

Engberding, R.

Bundeskriminalamt, ST 25,
Paul-Dickopf-Strasse 2,
D-53340 Meckenheim,
GERMANY
Fax: +4922258945456
E-mail: st25@bka.bund.de

Fasten, W.	AEA Technology QSA GmbH, Gieselweg 1, D-38110 Braunschweig, GERMANY Fax: +495307932337 E-mail: wolfgang.fasten@de.seat.com
Grasegger, R.	Amt für Militärkunde, P.O. Box 910138, D-12413 Berlin, GERMANY Fax: +493040890895901 E-mail: mvw_amk@gmx.de
Heinsberg, V.	Permanent Mission of Germany, Chemin du Petit-Saconnex 28c, CH-1211 Geneva 19, SWITZERLAND Fax: +41227301161 E-mail: mission.germany@ties.itu.int
Hinrichsen, H.-P.E.	Federal Ministry of Environment, Nature Conservation and Nuclear Safety, Referat RS II, Heinrich-von-Stephan-Strasse 1, D-53175 Bonn, GERMANY Fax: +4918883967
Hoffmann, H.J.	Federal Ministry of Environment, Nature Conservation and Nuclear Safety, P.O. Box 120629, D-53048 Bonn, GERMANY Fax: +4918883053967 E-mail: hans-joachim.hoffmann@bmu.bund.de
Kremer, S.	Federal Ministry of Environment, Nature Conservation and Nuclear Safety, P.O. Box 120629, D-53048 Bonn, GERMANY Fax: +491888052889 E-mail: susanne.kremer@bmu.bund.de

Michel, S.	Bundeskriminalamt, Referat ZD 11, Thaerstrasse 11, D-65173 Wiesbaden, GERMANY
Puchta, H.E.R.	Bavarian State Ministry for State Development and Environmental Affairs, Rosenkavalierplatz 2, D-81925 München, GERMANY Fax: +498992142289 E-mail: hermann.puchta@stmlu.bayern.de
Pundt, H.U.	Federal Ministry of Finance, Unit III B7, Customs Investigation, Langer Grabenweg 35, D-53175 Bonn, GERMANY Fax: +492286822500 E-mail: holger-uwe.pundt@bmf.bund.de
Reindl, B.	Permament Mission of the Federal Republic of Germany to the United Nations and the International Organizations, Wagramer Strasse 14, A-1220 Vienna, AUSTRIA Fax: +43126333756 E-mail: pol2V@wienio.auswaertiges-amt.de
Rudischhauser, W.	Permament Mission of the Federal Republic of Germany to the United Nations and the International Organizations, Wagramer Strasse 14, A-1220 Vienna, AUSTRIA Fax: +43126333756 E-mail: V@wienio.auswaertiges-amt.de
Schwarz, G.	Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) mbH, Schwertnergasse 1, D-50667 Köln, GERMANY

Sefzig, R. | Federal Ministry of Environment, Nature Conservation and Nuclear Safety,
P.O. Box 120629,
D-53048 Bonn,
GERMANY
Fax: +4918883053967
E-mail: renate.sefzig@bmu.bund.de

Sperlich, H. | Federal Ministry of the Interior,
Alt-Moabit 101 D,
D-10559 Berlin,
GERMANY
Fax: +4918886811960
E-mail: holger.sperlich@bmi.bund.de

Weber, H.W. | Hessisches Ministerium für Umwelt, Landwirtschaft und Forsten,
Mainzerstrasse 80,
D-65189 Wiesbaden,
GERMANY
Fax: +496118151945
E-mail: hw.weber@mulf.hessen.de

Weiss, W. | Bundesamt für Strahlenschutz,
P.O. Box 100149,
D-38201 Salzgitter,
GERMANY
Fax: +4918883332105
E-mail: wweiss@bfs.de

Ziegler, J. | Permament Mission of the Federal Republic of Germany to the United Nations and the International Organizations,
Wagramer Strasse 14,
A-1220 Vienna,
AUSTRIA
Fax: +43126333756
E-mail: inter@deubowien.at

GHANA

Amuasi, J.H. Ghana Atomic Energy Commission,
P.O. Box LG 80,
Legon – Accra,
GHANA
Fax: +22321400807
E-mail: secgaec@ncs.com.gh

Owusu, A.J. CEPS Laboratory,
Customs, Excise and Preventive Service,
P.O. Box KA 9046,
Airport – Accra,
GHANA
Fax: +23321512299
E-mail: angimmond@yahoo.co

Schandorf, C. Radiation Protection Institute,
Ghana Atomic Energy Commission,
P.O. Box LG 80,
Legon – Accra,
GHANA
Fax: +23321400807
E-mail: rpbgaec@ghana.com

GREECE

Alexandris, C. Permanent Mission of Greece
to the International Atomic Energy Agency,
Argentinierstrasse 14,
A-1040 Vienna,
AUSTRIA
Fax: +4315056217
E-mail: hellasemb@greekembassy.jet2web.at

Antonopoulos-Domis, M. Institute of Nuclear Technology and Radiation
Protection,
Demokritos National Center for Scientific Research,
Aghia Paraskevi,
GR-153 10 Athens,
GREECE
Fax: +30106545496
E-mail: antonop@ipta.demokritos.gr

Balakos, G. State Security Division,
Arms and Ammunition Department,
Hellenic Police Headquarters,
4 P. Kanellopoulou Street,
GR-10177 Athens,
GREECE
Fax: +302106924006
E-mail: registry@ipcd.gr

Fountoulaki, L. Ministry of Public Order,
4 P. Kanellopoulou Street,
GR-10177 Athens,
GREECE
Fax: +302107796991

Matikas, T. Division of Regulatory Control,
Safety and Radiation Protection,
Greek Atomic Energy Commission,
P.O. Box 60092,
GR-15310 Aghia Paraskevi – Attiki,
GREECE
Fax: +302106506762
E-mail: thmatik@eeae.gr

Papadimitropoulos, P. Permanent Mission of Greece
to the International Atomic Energy Agency,
Argentinierstrasse 14,
A-1040 Vienna,
AUSTRIA
Fax: +4315056217
E-mail: grembat@telecom.at

HAITI

Craan, G.M. Haitian Ministry for Public Health and Population,
Palais des Ministères,
Rue Monseigneur Guilloux,
Port au Prince,
HAITI
Fax: +5092493207
E-mail: gcraan@hotmail.com

Guiteau, J.P.
Haitian Ministry for Public Health and Population,
Palais des Ministères,
Rue Monseigneur Guilloux,
Port au Prince,
HAITI
Fax: +5092493207
E-mail: gjp84@hotmail.com or
guiteau2001@yahoo.com

HOLY SEE

Ferraris, M.
Permanent Mission of the Holy See
to the International Organizations in Vienna,
Theresianumgasse 33/4,
A-1040 Vienna,
AUSTRIA
Fax: +431505850175
E-mail: marco.ferraris@chello.at

Hefner, A.
Health Physics Division,
ARC Seibersdorf GmbH,
A-2444 Seibersdorf,
AUSTRIA
Fax: +43505502502
E-mail: alfred.hefner@arcs.ac.at

HUNGARY

Balla, J.
Institute of Isotopes Co. Ltd,
Konkoly Thege M. út 29–33,
H-1121 Budapest,
HUNGARY
Fax: +3613959082
E-mail: balla@izotop.kfkipark.hu

Bartha, A.
Hungarian Customs and Finance Guard,
Mester út 7,
H-1095 Budapest,
HUNGARY
Fax: +3614569530
E-mail: bartha.andras@mail.vpop.hu

Benesóczky, I.	Ministry of Defence, P.O. Box 25, H-1885 Budapest, HUNGARY Fax: +3614741126 E-mail: imre.benesoczki@hm.gov.hu
Horvath, I.	Permanent Mission of Hungary to the International Atomic Energy Agency, Bankgasse 4–6, A-1010 Vienna, AUSTRIA Fax: +4315356161 E-mail: un-mission@huembvie.at
Madar, I.	Ministry of Defence, P.O. Box 25, H-1885 Budapest, HUNGARY Fax: +3614741126 E-mail: imre.madar@hm.gov.hu
Molnári, S.	Permanent Mission of Hungary to the International Atomic Energy Agency, Bankgasse 4–6, A-1010 Vienna, AUSTRIA Fax: +4315356161 E-mail: smolnari@huembvie.at
Pellet, S.	Frederic Joliot Curie National Research Institute for Radiobiology and Radiohygiene, Anna út 5, H-1221 Budapest, HUNGARY Fax: +3612291931 E-mail: pellet@hp.osski.hu
Povázsai, S.	Hungarian National Police Headquarters, ORFK Igazgatásrendészeti Föosztály, Teve út 4–6, H-1139 Budapest, HUNGARY Fax: +3614435512 E-mail: povazsais@mail.orfk.b-m.hu

Rónaky, J.
Hungarian Atomic Energy Authority,
P.O. Box 676,
H-1539 Budapest 114,
HUNGARY
Fax: +3614364804
E-mail: ronaky@haea.gov.hu

Salgó, L.
Hungarian National Police Headquarters,
ORFK Igazgatásrendészeti Föosztály,
Teve út 4–6,
H-1139 Budapest,
HUNGARY
Fax: +3614435578 or +3614435579
E-mail: salgol@mail.orfk.b-m.hu

Vincze, A.
Department of NBC Defence and Environmental Security,
Miklos Zrinyi National Defence University,
P.O. Box 15, Hungarian KRT 9–11,
H-1587 Budapest,
HUNGARY
Fax: +3614329040
E-mail: vincze@zmne.hu

Volent, G.
Paks Nuclear Power Plant Ltd,
P.O. Box 71,
H-7031 Paks,
HUNGARY
E-mail: volent@npp.hu

ICELAND

Hreggvidsson, E.B.
Permanent Mission of Iceland to the International Atomic Energy Agency,
Naglergasse 2/8,
A-1010 Vienna,
AUSTRIA
Fax: +4315332774
E-mail: icedel.vienna@utn.stjr.is

INDIA

Deshpande, R.S.
Permanent Mission of India
to the International Atomic Energy Agency,
Kärntner Ring 2, 2nd Floor,
A-1010 Vienna,
AUSTRIA
Fax: +4315850805
E-mail: rsdesh@eoivien.vienna.at

Durai, S.
Permanent Mission of India
to the International Atomic Energy Agency,
Kärntner Ring 2, 2nd Floor,
A-1010 Vienna,
AUSTRIA
Fax: +43155059219
E-mail: cpolitical@indianembassy.at

Karkare, H.
Permanent Mission of India
to the International Atomic Energy Agency,
Kärntner Ring 2, 2nd Floor,
A-1010 Vienna,
AUSTRIA
Fax: +4315059219

Krishnamachari, G.
Radiation Safety System Division,
Bhabha Atomic Research Centre,
Trombay, Mumbai 400085,
INDIA
Fax: +912225505151
E-mail: charigk@yahoo.com

Pradeepkumar, K.S.
Radiation Safety System Division,
Bhabha Atomic Research Centre,
Trombay, Mumbai 400085,
INDIA
Fax: +912225505151
E-mail: pradeepks@roltanet.com

Rao, H.A.
Permanent Mission of India
to the International Atomic Energy Agency,
Kärntner Ring 2, 2nd Floor,
A-1010 Vienna,
AUSTRIA
Fax: +4315059219
E-mail: dcmvienna@indianembassy.at

Sreenivasan, T.P. Permanent Mission of India
to the International Atomic Energy Agency,
Kärntner Ring 2, 2nd Floor,
A-1010 Vienna,
AUSTRIA
Fax: +4315059219
E-mail: dcmvienna@indianembassy.at

Srivastava, G.P. Control Instrumentation Division,
Bhabha Atomic Research Centre,
Trombay, Mumbai 400085,
INDIA
Fax: +912225505151
E-mail: gyan25@yahoo.com

INDONESIA

Kustiono, A.S. Nuclear Energy Control Board (BAPETEN),
Jl. MH Thamrin 55,
Jakarta 10350,
INDONESIA
Fax: +62212301253
E-mail: a.kustiono@bapeten.org or

Kusumo, H. Nuclear Energy Control Board (BAPETEN),
Jl. MH Thamrin 55,
Jakarta 10350,
INDONESIA
Fax: +62212301253
E-mail: h.kusumo@bapeten.org

Ridwan, M. Nuclear Energy Control Board (BAPETEN),
Jl. MH Thamrin 55,
Jakarta 10350,
INDONESIA
Fax: +62212301253
E-mail: mridwan@bapeten.org

Sinaga, M. Nuclear Energy Control Board (BAPETEN),
Jl. MH Thamrin 55,
Jakarta 10350,
INDONESIA
Fax: +62212302281
E-mail: m.sinaga@bapeten.org

Yusuf, Z. Laboratory Center for Forensics,
Department of Police,
Puslabfor Mabes Polri,
Jl. Trunojoyo 3,
Jakarta 12110,
INDONESIA
Fax: +62217398028

Zahir, S. Permanent Mission of Indonesia to the
International Atomic Energy Agency,
Gustav-Tschermak-Gasse 5–7,
A-1180 Vienna,
AUSTRIA
Fax: +4314790557
E-mail: s.zahir@kbriwina.at

IRAN, ISLAMIC REPUBLIC OF

Esmaeili, A. Permanent Mission of the Islamic Republic of Iran
to the International Atomic Energy Agency,
Heinestraße 19/1/1,
A-1020 Vienna,
AUSTRIA
Fax: +4312140973
E-mail: esmaeili@teleweb.at

Ghiassi-Nejad, M. National Radiation Protection Department,
Atomic Energy Organization of Iran (AEOI),
End of North Kargar Avenue,
P.O. Box 14155-4494, Tehran 14374,
ISLAMIC REPUBLIC OF IRAN
Fax: +98218009502
E-mail: ghiassi@mailcity.com

Madadi Zadeh, M. Atomic Energy Organization of Iran (AEOI),
P.O. Box 11365-3486,
Tehran,
ISLAMIC REPUBLIC OF IRAN
Fax: +98218021415
E-mail: mzaker@seai.neda.net.ir

Naderi, H. National Nuclear Safeguards Department,
Atomic Energy Organization of Iran (AEOI),
End of North Kargar Avenue,
P.O. Box 14155-4495, Tehran 14374,
ISLAMIC REPUBLIC OF IRAN
Fax: +98218009051
E-mail: hnaderi@aeoi.org.ir

Salehi, A.A. Permanent Mission of the Islamic Republic of Iran
to the International Atomic Energy Agency,
Heinestraße 19/1/1,
A-1020 Vienna,
AUSTRIA
Fax: +4312140973
E-mail: a.salehi@mailcity.com

IRAQ

Sabri, A.W. Permanent Mission of Iraq
to the International Atomic Energy Agency,
Johannesgasse 26,
A-1010 Vienna,
AUSTRIA
Fax: +4317136720

IRELAND

Hone, C. Radiological Protection Institute of Ireland,
3 Clonskeagh Square,
Clonskeagh Road,
Dublin 14,
IRELAND
Fax: +35312605797
E-mail: chone@rpii.ie

ISRAEL

Keren, M. Radiation and Noise Abatement Department,
Ministry of the Environment,
5 Kanfei Nesharim Street,
P.O. Box 34033,
95464 Jerusalem
ISRAEL
Fax: +97226516632
E-mail: moshek@environment.gov.lt

ITALY

Belli, M.	Laboratorio di Fisica, Istituto Superiore di Sanità, Viale Regina Elena 299, I-00161 Rome, ITALY Fax: +390649387075 E-mail: direzione.fisica@iss.it
Cavuoto, U.	Italian Agency for New Technology, Energy and the Environment (ENEA), Lungotevere Thaon di Revel 76, I-00196 Rome, ITALY Fax: +390636272739 E-mail: cavuoto@sede.enea.it
Mascia, G.L.	Permanent Mission of Italy to the International Atomic Energy Agency, Hoher Markt 8–9, A-1010 Vienna, AUSTRIA Fax: +431535162935
Matteocci, L.	Italian Agency for Environmental Protection and for Technical Services (APAT), Via Vitaliano Brancati 48, I-00144 Rome, ITALY Fax: +390650072941 E-mail: matteocci@apat.it
Menga, A.	Reparto Operativo del Comando Carabinieri per la Tutela dell'Ambiente di Roma, Largo L. Mossa 8A, I-00165 Rome, ITALY E-mail: antoniomenga@katamail.com
Moreno, C.	Permanent Mission of Italy to the International Atomic Energy Agency, Hoher Markt 8–9, A-1010 Vienna, AUSTRIA Fax: +431535162935

Orsini, A.

Italian Agency for New Technology, Energy and the Environment (ENEA),
C.R. Casaccia,
Via Anguillarese 301,
S. Maria di Galeria,
I-00060 Rome,
ITALY
Fax: +39630483147
E-mail: alberto.orsini@casaccia.enea.it

Torti, A.

Office of the Prime Minister,
Palazzo Chigi,
I-00194 Rome,
ITALY

Zeppa, P.

Italian Agency for Environmental Protection and for Technical Services (APAT),
Via Vitaliano Brancati 48,
I-00144 Rome,
ITALY
Fax: +390650072941
E-mail: zeppa@apat.it

JAMAICA

Watson, C.

Ministry of Commerce, Science and Technology,
36 Trafalgar Road,
Kingston 10,
JAMAICA
Fax: +8769682082
E-mail: cwatson@mct.gov.jm

JAPAN

Hirose, K.

Ministry of Education, Culture, Sports, Science and Technology (MEXT),
1-3-2 Kasumigaseki, Chiyoda-ku,
Tokyo 100-8966,
JAPAN
Fax: +81352534008
E-mail: khirose@mext.go.jp

Kaneko, T.
Permanent Mission of Japan
to the International Atomic Energy Agency,
Andromeda Tower, 23rd Floor,
Donau-City-Strasse 6,
A-1220 Vienna,
AUSTRIA
Fax: +4312636750
E-mail: pmj.iaeansg@atnet.at

Kawakami, Y.
Permanent Mission of Japan
to the International Atomic Energy Agency,
Andromeda Tower, 23rd Floor,
Donau-City-Strasse 6,
A-1220 Vienna,
AUSTRIA
Fax: +4312636750

Kusama, K.
Japan Radioisotope Association,
2-28-45 Honkomagome, Bunkyo-ku,
Tokyo 113-8941,
JAPAN
Fax: +81353958054
E-mail: kusama@jrias.or.jp

Saito, T.
Nuclear Safety Division,
Ministry of Education, Culture, Sports,
Science and Technology (MEXT),
1-3-2 Kasumigaseki, Chiyoda-ku,
Tokyo 100-8966,
JAPAN
Fax: +81352534048
E-mail: saitota@mext.go.jp

Shinozaki, M.
Permanent Mission of Japan
to the International Atomic Energy Agency,
Andromeda Tower, 23rd Floor,
Donau-City-Strasse 6,
A-1220 Vienna,
AUSTRIA
Fax: +4312636750
E-mail: pmj.iaeansg@atnet.at

Takasu, Y.

Permanent Mission of Japan
to the International Atomic Energy Agency,
Andromeda Tower, 23rd Floor,
Donau-City-Strasse 6,
A-1220 Vienna,
AUSTRIA
Fax: +4312636750
E-mail: pmj.iaeansg@atnet.at

Umezawa, H.

Cabinet Office,
Secretariat of the Nuclear Safety Commission,
3-1-1 Kasumigaseki, Chiyoda-ku,
Tokyo 100-8970,
JAPAN
Fax: +81225819839
E-mail: hyamamo2@op.cao.go.jp

Yamamoto, H.

Cabinet Office,
Secretariat of the Nuclear Safety Commission,
3-1-1 Kasumigaseki, Chiyoda-ku,
Tokyo 100-8970,
JAPAN
Fax: +81335819839
E-mail: hyamamo2@op.cao.go.jp

JORDAN

Al Rafie, S.N.

Permanent Mission of Jordan
to the International Atomic Energy Agency,
Doblhoffgasse 3/2,
A-1010 Vienna,
AUSTRIA
Fax: +4314501031
E-mail: jordanembassy@aon.at

Al-Shamayleh, J.

Permanent Mission of Jordan
to the International Atomic Energy Agency,
Doblhoffgasse 3/2,
A-1010 Vienna,
AUSTRIA
Fax: +4314501031
E-mail: jordanembassy@aon.at

Touq, M. | Permanent Mission of Jordan
to the International Atomic Energy Agency,
Doblhoffgasse 3/2,
A-1010 Vienna,
AUSTRIA
Fax: +4314051031

KAZAKHSTAN

Chelnokov, S.Y. | Atomic Energy Committee of the
Republic of Kazakhstan,
Lisa Chaikina Street 4,
P.O. Box 480020,
Almaty,
KAZAKHSTAN
Fax: +73272633356
E-mail: S.Chelnokov@atom.almaty.kz

Zhantikin, T. | Atomic Energy Committee of the
Republic of Kazakhstan,
Lisa Chaikina Street 4,
P.O. Box 480020,
Almaty,
KAZAKHSTAN
Fax: +73272633356
E-mail: t.zhantikin@atom.almaty.kz or
timur@nursat.kz

KENYA

Githii, W. | Ministry of Energy,
P.O. Box 30582,
Nairobi,
KENYA
Fax: +2542240910
E-mail: pro@energymin.go.ke

Juma, C.G. | Criminal Investigation Department,
Milimani Road,
P.O. Box 30036,
Nairobi,
KENYA
Fax: +25422713279
E-mail: ncst@insightkenya.com

Kamande, J.K. — Radiation Protection Board,
NSSF Building, 22nd Floor,
Western Wing, Block A,
Bishop Road,
P.O. Box 1984,
Nairobi,
KENYA
Fax: +2542714383
E-mail: rpbkenya@nbnet.co.ke

King'oriah, G.K. — National Council for Science and Technology,
P.O. Box 30623,
Nairobi,
KENYA
Fax: +2542213215 or +2542219018
E-mail: ncst@insightkenya.com

Ochieng, F.T. — Permanent Mission of Kenya
to the International Atomic Energy Agency,
Neulinggasse 29/8,
A-1030 Vienna,
AUSTRIA
Fax: +4317123922

Riaroh, D. — Ministry of Energy,
P.O. Box 30582,
Nairobi,
KENYA
Fax: +2542240910
E-mail: driaroh@energymin.go.ke

KOREA, REPUBLIC OF

Gi Hwan Kim — Ministry of Science and Technology,
Government Complex II,
Gwacheon City,
Kyunggi-Do 427-715,
REPUBLIC OF KOREA
Fax: +8215037678
E-mail: ghkim@most.go.kr

Kim Dong Il	Korea Institute of Nuclear Safety, 19 Goosung-Dong, Yusong-ku, Taejon 305-600, REPUBLIC OF KOREA Fax: +82428684042 E-mail: k232kdi@kins.re.kr
Kim Seon Bin	Ministry of Science and Technology, Government Complex II, Gwacheon City, Kyunggi-Do 427-715, REPUBLIC OF KOREA E-mail: Kimsb@most.go.kr
Kim Yong-Hwan	Permanent Mission of the Republic of Korea to the International Atomic Energy Agency, Gregor-Mendel-Strasse 25, A-1180 Vienna, AUSTRIA Fax: +4314781013 E-mail: yhk113@yahoo.co.kr
Na Ho Seong	Radiation Safety Department, Korea Institute of Nuclear Safety, 19 Ku Sung Dong, Yuseong Ku, Taejon 305-600, REPUBLIC OF KOREA Fax: +82114022071 E-mail: shna@kins.re.kr
Oh KyUng Ho	Ministry of Science and Technology, Government Complex II, Gwacheon City, Kyunggi-Do 427-715, REPUBLIC OF KOREA Fax: +8225037676 E-mail: ohho@most.go.kr

KUWAIT

Al Mulla, N.

Permanent Mission of Kuwait
to the International Atomic Energy Agency,
Universitätsstrasse 5/II,
A-1010 Vienna,
AUSTRIA
Fax: +431405564613
E-mail: kuwaitem@eunet.at

Al-Khalid, R.

Permanent Mission of Kuwait
to the International Atomic Energy Agency,
Universitätsstrasse 5/II,
A-1010 Vienna,
AUSTRIA
Fax: +431405564613
E-mail: kuwaitem@eunet.at

Al-Ramadhan, M.

Permanent Mission of Kuwait
to the International Atomic Energy Agency,
Universitätsstrasse 5/II,
A-1010 Vienna,
AUSTRIA
Fax: +431405564613
E-mail: kuwaitem@eunet.at

LATVIA

Medins, J.

Security Police,
Kr. Barona Street 99a,
LV-1012 Riga,
LATVIA
Fax: +3712273373
E-mail: medi@dp.gov.lv

Salmins, A.

Radiation Safety Centre,
Maskavas iela 165,
LV-1019 Riga,
LATVIA
Fax: +3717032659
E-mail: A.Salmins@rdc.gov.lv

LEBANON

El Samad, O. | Conseil national de la recherche scientifique (CNRS),
Boulevard de la Cité Sportive,
B.P. 11-8281,
Beirut,
LEBANON
Fax: +9611450810
E-mail: osamad@cnrs.edu.lb

LIBYAN ARAB JAMAHIRIYA

Fawaris, B.H. | Department of Planning and Information,
Tajoura Nuclear Research Centre (TNRC),
P.O. Box 464,
Tripoli,
LIBYAN ARAB JAMAHIRIYA
Fax: +218213614143

Kharaza, S. | Tajoura Nuclear Research Centre (TNRC),
P.O. Box 30878,
Tripoli,
LIBYAN ARAB JAMAHIRIYA
Fax: +218213614143
E-mail: salah_khraraza@yahoo.com

LITHUANIA

Adomavicius, S. | Permanent Mission of Lithuania to the International Atomic Energy Agency,
Löwengasse 47/1/Top 8,
A-1030 Vienna,
AUSTRIA
Fax: +4317199759

Kutas, S.A.B. | State Nuclear Power Safety Inspectorate (VATESI),
Sermuksniu 3,
LT-2600 Vilnius,
LITHUANIA
Fax: +3702614487
E-mail: atom@vatesi.lt

Maksimovas, G. Permanent Mission of Lithuania to the International Atomic Energy Agency,
Löwengasse 47/1/Top 8,
A-1030 Vienna,
AUSTRIA
Fax: +4317187141
E-mail: Gytis.Maksimovas@aon.at

Semaskevic, V. Ignalina Nuclear Power Plant,
Taikos 42-12,
LT-4761 Visaginas,
LITHUANIA
Fax: +370356331317
E-mail: semaskevic@mail.iae.lt

Stasiunaitiene, R.M. Radiation Protection Centre,
Kalvariju 153,
LT-2042 Vilnius,
LITHUANIA
Fax: +37052754692
E-mail: r.stasiunaitiene@rsc.lt

Zymancius, Z. State Border Guard Service,
Savanoriu 2,
LT-2009 Vilnius,
LITHUANIA
Fax: +37052126396
E-mail: zen@mail.lt

LUXEMBOURG

Feider, M. Radiation Protection Department,
Ministry of Health,
Villa Louvigny, Allée Marconi,
L-2120 Luxembourg,
LUXEMBOURG
Fax: +352467521
E-mail: michel.feider@tns.lu

MADAGASCAR

Mohajy, A. Ministry of Foreign Affairs,
B.P. 836, Anosy,
Antananarivo,
MADAGASCAR
Fax: +261202230475 or +261202234484

Zafimanjato, J.L.R. | Institut national des sciences et techniques nucléaires (INSTN),
B.P. 4279,
101 Antananarivo,
MADAGASCAR
Fax: +261202235583
E-mail: instn@dts.mg

MALAYSIA

Dahalan, R. | Atomic Energy Licensing Board,
Batu 24, Jalan Dengkil,
43800 Sepang,
Selangor Darul Ehsan,
MALAYSIA
Fax: +60389223685
E-mail: kp@aelb.gov.my

Daud, M. | Malaysian Institute for Nuclear Technology Research (MINT),
43000 Bangi, Kajang,
Selangor Darul Ehsan,
MALAYSIA
Fax: +60389253827
E-mail: daud@mint.gov.my

Lam Yook Choi | Training Division, Royal Malaysian Police,
50560 Bukit Aman,
Kuala Lumpur,
MALAYSIA
Fax: +60320728822
E-mail: lamlam009@pd.jaring.my

Raja Adnan, R.A.A. | Permanent Mission of Malaysia to the International Atomic Energy Agency,
Prinz Eugen-Strasse 18,
A-1040 Vienna,
AUSTRIA
Fax: +4315057942
E-mail: sa.malaysia@eunet.at

Sudin, M.Y.
Atomic Energy Licensing Board,
Batu 24, Jalan Dengkil,
43800 Sepang,
Selangor Darul Ehsan,
MALAYSIA
Fax: +60340415855
E-mail: yasin@aelb.gov.my

MALI

Diakite, S.
Direction nationale de l'énergie,
B.P. 1872,
Cres Badalabau Bay,
Bamako,
MALI
Fax: +2232237396
E-mail: dnenergy@afribone.net.ml

Traore, M.
Direction nationale de la protection civile,
Bamako,
MALI
Fax: +2232236353

MALTA

Brejza, P.S.
Occupational Health and Safety Authority,
120 St. Ursola Street,
Valletta, VLT02,
MALTA
Fax: +35621232909
E-mail: paul.brejza@gov.mt

Tabone, A.
Civil Protection Department,
Ta'Kandja Siggiewi, CMR02,
MALTA
Fax: 0035621462605
E-mail: albert.tabone@gov.mt

MARSHALL ISLANDS

Capelle, D.F.
Ministry of Foreign Affairs,
P.O. Box 1349,
Majuro, MH 96960,
MARSHALL ISLANDS
Fax: +6926254979
E-mail: mofat@ntamar.com

MEXICO

Ajuria Garza, S.
Secretaría de Energía,
Insurgentes Sur 890, Piso 12,
Col. del Valle,
03100 Mexico, D.F.,
MEXICO
Fax: +525554486094
E-mail: sajuria@energia.gob.mx

Campuzano, L.
Permanent Mission of Mexico
to the International Atomic Energy Agency,
Operngasse 21/10,
A-1040 Vienna,
AUSTRIA
Fax: +4313107387
E-mail: embamex@embamex.or.at

Espinosa Cantellano, P.
Permanent Mission of Mexico
to the International Atomic Energy Agency,
Operngasse 21/10,
A-1040 Vienna,
AUSTRIA
Fax: +4313107387
E-mail: embamex@embamex.or.at

Hidalgo Castellanos, J.L.
Permanent Mission of Mexico
to the International Atomic Energy Agency,
Operngasse 21/10,
A-1040 Vienna,
AUSTRIA
Fax: +4313107387
E-mail: embamex@embamex.or.at

Reyes Sanchez, M.A.
Comisión Nacional de Seguridad Nuclear y
Salvaguardias,
Dr. Barragan 779, Piso 2,
Col. Narvarte,
Delegación Benito Juarez,
03020 Mexico, D.F.,
MEXICO
Fax: +525550953292

Rodriguez Montero, M.
Secretaría de Energía,
Insurgentes Sur 890, Piso 12,
Col. del Valle,
03100 Mexico, D.F.,
MEXICO
Fax: +525554486094
E-mail: mrodriguez@energia.gob.mx

MONGOLIA

Boldbaatar, B.
General Police Department,
Sambuugiin gudamj 18,
P.O. Box 123,
Ulaanbaatar 38,
MONGOLIA
Fax: +97611322057
E-mail: badarchg@yahoo.com

Oyuntulkhuur, N.
Nuclear Regulatory Authority,
11th Governmental Building 1109,
Sambuugiin gudamj 11,
P.O. Box 856,
Ulaanbaatar 46,
MONGOLIA
Fax: +97611453950
E-mail: monnra@mbox.mn

MOROCCO

Bouabdellaoui, Y.
Institut agronomique et vétérinaire Hassan II,
Université Mohammed V Agdal,
3, rue Michlifen,
Rabat,
MOROCCO
Fax: +21237774676
E-mail: y.bouabdellaoui@iav.ac.ma

Boutaleb, H.J.
Université Mohammed V Agdal,
3, rue Mechlifen,
B.P. 455,
Rabat,
MOROCCO
Fax: +21237671401
E-mail: presidence@um5a.ac.ma

Laassel, A. Ministère des affaires étrangères et de la coopération,
Avenue Franklin Roosevelt,
10000 Rabat,
MOROCCO
Fax: +21237765508
E-mail: laassela@maec.gov.ma

MYANMAR

Kyaw Soe Ministry of Science and Technology,
6, Kaba Aye Pagoda Road,
Yankin 11081,
Yangon,
MYANMAR
Fax: +9501650685
E-mail: dae.myatom@mptmail.net.mm

Oo Ko Ko Department of Atomic Energy,
Ministry of Science and Technology,
6, Kaba Aye Pagoda Road,
Yankin 11081,
Yangon,
MYANMAR
Fax: +951650685
E-mail: dae.myatom@mptmail.net.mm

NAMIBIA

Awasab, E. Ministry of Health and Social Services,
Private Bag 13198,
Windhoek 9000,
NAMIBIA
Fax: +264612032765
E-mail: windhoekeawaseb@mhss.gov.na

Embumbulu, E. National Radiation Protection Services,
Ministry of Health and Social Services,
Private Bag 13198, P.O. Box 7632,
Windhoek 9000,
NAMIBIA

NETHERLANDS

Boogaard, J.P.

Quality, Safety and Environment,
Nuclear Research and Consultancy Group (NRG),
P.O. Box 25,
NL-1755 ZG Petten,
NETHERLANDS
Fax: +31224568912
E-mail: boogaard@nrg-nl.com

Codée, H.D.K.

COVRA NV,
Postbus 202,
NL-4380 AE Vlissingen,
NETHERLANDS
Fax: +31113616650
E-mail: hccovra@zeelandnet.nl

Kop, D.J.

Permanent Mission of the Netherlands
to the International Atomic Energy Agency,
Opernring 5,
A-1010 Vienna,
AUSTRIA
Fax: +43158939267
E-mail: wev@minbuza.nl

NEW ZEALAND

Bridge, B.

Permanent Mission of New Zealand
to the International Atomic Energy Agency,
Mattiellistrasse 2–4/3
A-1040 Vienna,
AUSTRIA
Fax: +4315053020

Turnbull, J.

National Radiation Laboratory,
P.O. Box 25-099,
Christchurch,
NEW ZEALAND
Fax: +6433661156
E-mail: jim_turnbull@nrl.moh.govt.nz

Waetford, W.

Permanent Mission of New Zealand
to the International Atomic Energy Agency,
Mattiellistrasse 2–4/3,
A-1040 Vienna,
AUSTRIA
Fax: +4315053020

NICARAGUA

Altiamirano Lacayo, A. — Permanent Mission of Nicaragua
to the International Atomic Energy Agency,
Ebendorferstrasse 10/3/12,
A-1010 Vienna,
AUSTRIA
Fax: +4314032752

Gallo, S.R. — Ministerio de Gobernación,
Barrio San Judas del Ceibo 31/2 c al oeste,
Managua,
NICARAGUA
Fax: +5052224074
E-mail: salvadorgallo200@yahoo.com

NIGER

Soumana, S. — Institut des radioisotopes,
Université Abdou Moumouni,
B.P. 10727,
Niamey,
NIGER
Fax: +227733862
E-mail: ssoumana@yahoo.com

NIGERIA

Elegba, S.B. — Nigerian Nuclear Regulatory Authority,
Plot 701C, Central Area,
P.M.B. 559,
Garki, Abuja,
NIGERIA
Fax: +23495234924
E-mail: nnra@linkserve.com; sbelegba@yahoo.com

Mustapha, A.A. — Nigeria Customs Service Headquarters,
Abidjan Street, Wuse Zone 3,
Abuja,
NIGERIA
Fax: +23495234690

NORWAY

Ugletveit, F. — Norwegian Radiation Protection Authority,
Grini Naeringspark 13,
P.O. Box 55,
N-1332 Østeras,
NORWAY
Fax: +476714707
E-mail: finn.ugletveit@nrpa.no

Wohni, T. — Norwegian Radiation Protection Authority,
Grini Naeringspark 13,
P.O. Box 55,
N-1332 Østeras,
NORWAY
Fax: +4767147407
E-mail: tor.wohni@nrpa.no

PAKISTAN

Hashimi, J.A. — Pakistan Nuclear Regulatory Authority,
P.O. Box 1912,
Islamabad,
PAKISTAN
Fax: +92519204112
E-mail: officialmail@pnra.gov.pk or
jawad.hashimi@hq.pnra.gov.pk

Mahmood, K. — Pakistan Atomic Energy Commission,
P.O. Box 1114,
Islamabad,
PAKISTAN
Fax: +92519204908

Mansoor, M.I. — Advisor Security, NCA,
9B Hali Road, Westbridge I,
Rawalpindi Cantt,
PAKISTAN
Fax: +519278109

Orfi, S.D. — HPD, PINSTECH,
P.O. Nilore,
Islamabad,
PAKISTAN
Fax: +92519290275
E-mail: orfi@pinstech.org.pk

PANAMA

Douglas, A.

Radiological Health Department,
Social Security Agency,
Apartado 2939 Balboa,
Panama,
PANAMA
Fax: +5072691363
E-mail: alejandrodouglas@hotmail.com

Halphen Pérez, J.E.

Permanent Mission of Panama
to the International Atomic Energy Agency,
Elisabethstrasse 4/5/4/10,
A-1010 Vienna,
AUSTRIA
Fax: +4315863080
E-mail: mail@empanvienna.co.at

PARAGUAY

Aguilera, C.

Permanent Mission of Paraguay
to the International Atomic Energy Agency,
Prinz Eugen-Strasse 18/1/2/7,
A-1040 Vienna,
AUSTRIA
Fax: +4319419898
E-mail: embaparviena@chello.at

Cabello Sarubbi, O.

Permanent Mission of Paraguay
to the International Atomic Energy Agency,
Prinz Eugen-Strasse 18/1/2/7,
A-1040 Vienna,
AUSTRIA
Fax: +4319419898
E-mail: embaparviena@chello.at

Romero de Gonzalez, V.

Comisión Nacional de Energía Atómica,
Campus Universitario,
Ruta 2, Mcal. Estigarribia, km 11,
San Lorenzo,
PARAGUAY
Fax: +59521585618
E-mail: cnea@sce.cnc.una.py

PERU

Azurin Araujo, C.
Permanent Mission of Peru
to the International Atomic Energy Agency,
Gottfried-Keller-Gasse 2/8/36,
A-1030 Vienna,
AUSTRIA
Fax: +4317127704
E-mail: embperu.austria@peru.jet2web.at

Paulinich, J.
Permanent Mission of Peru
to the International Atomic Energy Agency,
Gottfried-Keller-Gasse 2/8/36,
A-1030 Vienna,
AUSTRIA
Fax: +4317127704
E-mail: embperu.austria@peru.jet2web.at

Portugal, H.
Permanent Mission of Peru
to the International Atomic Energy Agency,
Gottfried-Keller-Gasse 2/8/36,
A-1030 Vienna,
AUSTRIA
Fax: +4317127704
E-mail: embperu.austria@peru.jet2web.at

Reyes Pacheco, C.A.M.
Dirección Contra el Terrorismo de la
Policía Nacional del Perú (DIRCOTE),
Avenida España s/n,
Local Prefectual,
Lima,
PERU
Fax: +5114316324
E-mail: azulcrp@yahoo.com

PHILIPPINES

Mateo, A.J.
Philippine Nuclear Research Institute,
Commonwealth Avenue,
Diliman,
Quezon City 1101,
PHILIPPINES
Fax: +6329201646
E-mail: ajmateo@pnri.dost.gov.ph

Mier, A.F.J.
National Security Council,
5 Luna Road, corner East Avenue,
Diliman,
Quezon City 1100,
PHILIPPINES
Fax: +63292785372
E-mail: kyttmier@netscape.net

POLAND

Lada, W.
National Atomic Energy Agency,
Krucza Street 36,
PL-00921 Warsaw,
POLAND
Fax: +48226959848
E-mail: witold.lada@paa.gov.pl

Smagala, G.
Central Laboratory for Radiological Protection,
Konwaliowa Street 7,
PL-03194 Warsaw,
POLAND
Fax: +48228111616
E-mail: clor@mercury.ci.uw.edu.pl

PORTUGAL

Carvalho, F.P.
Department of Radiological Protection and Nuclear Safety,
Nuclear and Technology Institute,
Estrada Nacional 10,
P-2686-953 Sacavem,
PORTUGAL
Fax: +351219941995
E-mail: dprsn@itn.mces.pt

QATAR

Al-Emadi, W.M.
Supreme Council for the Environment and Natural Reserves,
P.O. Box 7634,
Doha,
QATAR
Fax: +9744415246
E-mail: wmwmadi@mmaa.gov.qa

Al Khatibeh, A.J.A.
Supreme Council for the Environment
and Natural Reserves,
P.O. Box 7634,
Doha,
QATAR
Fax: +9744415246

Al Mulla, A.Y.
Permanent Mission of Qatar
to the International Atomic Energy Agency,
Währingerstrasse 2–4/24–25,
A-1092 Vienna,
AUSTRIA
Fax: +4313190897

REPUBLIC OF MOLDOVA

Andries, A.
Academy of Sciences of Moldova,
1, Boulevard Stefan cel Mare,
MD-2001 Chisinau,
MOLDOVA
Fax: +3732276014
E-mail: andries@asm.md

Balan, I.
State Department for Standards and Metrology
of the Republic of Moldova,
180, Boulevard Stefan cel Mare,
MD-2004 Chisinau,
MOLDOVA
Fax: +3732247292
E-mail: balandsr@yahoo.com

ROMANIA

Baciu, A.-M.
General Inspectorate of Romanian Police,
Calea Victoriei 7, Sector 3,
Bucharest,
ROMANIA
Fax: +40213111579
E-mail: corado@fx.ro or dgccoacbls2@igp.ro

Biro, L.

National Commission for Nuclear Activities Control,
Bulevardul Libertatii 14,
P.O. Box 42-4,
RO-761061 Bucharest 5,
ROMANIA
Fax: +4013373887
E-mail: lucian.biro@cncan.ro

Bota, L.

Permanent Mission of Romania
to the International Atomic Energy Agency,
Seilerstätte 17/3, Top 10–11,
A-1010 Vienna,
AUSTRIA
Fax: +4315129057
E-mail: mpromviena@magnet.at

Golumbeanu, R.

Ministry of Foreign Affairs,
Calea Victoriei 1,
Bucharest,
ROMANIA

Popescu, D.

National Agency for Atomic Energy (ANEA),
21–25 Mendeleev Street,
RO-70168 Bucharest,
ROMANIA
Fax: +40213128707
E-mail: dpopescu@met.ro

Tanasescu, S.

Permanent Mission of Romania
to the International Atomic Energy Agency,
Seilerstätte 17/3, Top 10–11,
A-1010 Vienna,
AUSTRIA
Fax: +4315129057
E-mail: mpromviena@magnet.at

Valeca, S.C.

Ministry of Education and Research,
21–25 Mendeleev Street,
RO-70168 Bucharest,
ROMANIA
Fax: +40213121410
E-mail: svaleca@met.ro

RUSSIAN FEDERATION

Agapov, A.M.	Ministry of the Russian Federation for Atomic Energy (Minatom), 24/26 Bolshaya Ordynka, RU-109180 Moscow, RUSSIAN FEDERATION Fax: +70959535484 E-mail: agapov@minatom.ru
Arutyunyan, R.V.	Nuclear Safety Institute (IBRAE), Russian Academy of Sciences, 52 Bolshaya Tulskaya Street, RU-113191 Moscow, RUSSIAN FEDERATION Fax: +70959580040 E-mail: arut@ibrae.ac.ru
Averikiev, V.	Permanent Mission of the Russian Federation to the International Atomic Energy Agency, Erzherzog-Karl-Strasse 182, A-1220 Vienna, AUSTRIA Fax: +4312805687 E-mail: rf.mission@atnet.at
Barinov, A.S.	MOS NPO RADON, 7 Rostovskij Pereulok 2/14, RU-119121 Moscow, RUSSIAN FEDERATION Fax: +70952481941
Belyaeva, M.P.	Ministry of the Russian Federation for Atomic Energy (Minatom), 24/26 Bolshaya Ordynka, RU-109180 Moscow, RUSSIAN FEDERATION Fax: +70952302420

Berchik, V.P. | Situation and Crisis Center,
Ministry of the Russian Federation for Atomic Energy (Minatom),
24/26 Bolshaya Ordynka,
RU-109180 Moscow,
RUSSIAN FEDERATION
Fax: +70952392875
E-mail: dispetcher@skc.ru

Berdennikov, G. | Permanent Mission of the Russian Federation to the International Atomic Energy Agency,
Erzherzog-Karl-Strasse 182,
A-1220 Vienna,
AUSTRIA
Fax: +4312805687
E-mail: rf.mission@atnet.at

Boiko, Y. | Parliament of the Russian Federation,
State Duma,
Georgievski Pereulok 2,
RU-103265 Moscow,
RUSSIAN FEDERATION
Fax: +70952925358
E-mail: boy@duma.gov.ru

Bolshov, L.A. | Nuclear Safety Institute (IBRAE),
Russian Academy of Sciences,
52 Bolshaya Tulskaya Street,
RU-113191 Moscow,
RUSSIAN FEDERATION
Fax: +70959580040
E-mail: bolshov@ibrae.ac.ru

Burdukov, P.T. | Parliament of the Russian Federation,
State Duma,
Georgievski Pereulok 2,
RU-103265 Moscow,
RUSSIAN FEDERATION
Fax: +70952926023

Bykov, A. | Ministry of the Russian Federation for Atomic Energy (Minatom),
24/26 Bolshaya Ordynka,
RU-109180 Moscow,
RUSSIAN FEDERATION
Fax: +70952302420

Bykov, I.
Permanent Mission of the Russian Federation
to the International Atomic Energy Agency,
Erzherzog-Karl-Strasse 182,
A-1220 Vienna,
AUSTRIA
Fax: +4312805687

Davidchuk, S.
Permanent Mission of the Russian Federation
to the International Atomic Energy Agency,
Erzherzog-Karl-Strasse 182,
A-1220 Vienna,
AUSTRIA
Fax: +4312805687

Gutsalov, A.
Federal Nuclear and Radiation Safety Authority
of the Russian Federation (Gosatomnadzor),
Taganskaya Street 34,
RU-109147 Moscow,
RUSSIAN FEDERATION
Fax: +70959124041
E-mail: gutsalov@gan.ru

Ilyin, L.A.
Institute of Biophysics, State Research Center,
Ministry of Public Health,
Zhivopisnaya Street 46,
RU-123182 Moscow,
RUSSIAN FEDERATION
Fax: +70951903590

Klishina, N.A.
Ministry of the Russian Federation for
Atomic Energy (Minatom),
Staromonetny Pereulok 26,
RU-109180 Moscow,
RUSSIAN FEDERATION
Fax: +7095 2302420
E-mail: klishina@diec.skc.ru

Kochetkov, O.A.
Institute of Biophysics, State Research Center,
Ministry of Public Health,
Zhivopisnaya Street 46,
RU-123182 Moscow,
RUSSIAN FEDERATION
Fax: +70951903590
E-mail: kochetkov@srcibph.ru; ibphgen@rcibph.dol.ru

Kornysheva, E.Y. Izdatelski Dom Kommersant,
ul. Vrubelya 4,
RU-125080 Moscow,
RUSSIAN FEDERATION
Fax: +70959439761

Kuchinov, V.P. Ministry of the Russian Federation for
Atomic Energy (Minatom),
24/26 Bolshaya Ordynka,
RU-109180 Moscow,
RUSSIAN FEDERATION
Fax: +70952302420

Kutsenko, V. Ministry of the Russian Federation for
Atomic Energy (Minatom),
24/26 Bolshaya Ordynka,
RU-109180 Moscow,
RUSSIAN FEDERATION
Fax: +70952302420

Kuzelev, N.R. Russian National Technical Physics
and Automation Research Institute,
Minatom,
Varshavskoye Shosse 46,
RU-115230 Moscow,
RUSSIAN FEDERATION
Fax: +70951115434

Kuznetsova, O. Permanent Mission of the Russian Federation
to the International Atomic Energy Agency,
Erzherzog-Karl-Strasse 182,
A-1220 Vienna,
AUSTRIA
Fax: +4312805687

Kvok, B.D. Permanent Mission of the Russian Federation
to the International Atomic Energy Agency,
Erzherzog-Karl-Strasse 182,
A-1220 Vienna,
AUSTRIA
Fax: +4312805687
E-mail: rf.mission@atnet.at

Maksimenko, A.
Production Association Mayak,
Lenin Street 31,
RU-454065 Chelyabinsk 65,
RUSSIAN FEDERATION
Fax: +70953517123826

Martynov, B.A.
Parliament of the Russian Federation,
State Duma,
Georgievski Pereulok 2,
RU-103265 Moscow,
RUSSIAN FEDERATION
Fax: +70952926023

Minin, Y.
Permanent Mission of the Russian Federation to the International Atomic Energy Agency,
Erzherzog-Karl-Strasse 182,
A-1220 Vienna,
AUSTRIA
Fax: +4312805687

Murin, M.
Ministry of Health,
Volokolamskaya 30,
RU-123182 Moscow,
RUSSIAN FEDERATION
Fax: +70951903590

Nesterov, V.
Federal State Unitary Enterprise,
All-Regional Corporation Izotop,
Pogodinskaya Street 22,
RU-119435 Moscow,
RUSSIAN FEDERATION
Fax: +70952450790

Novikov, G.A.
Department for Safety, Ecology and Emergency Situations,
Ministry of the Russian Federation for Atomic Energy (Minatom),
24/26 Bolshaya Ordynka,
RU-109180 Moscow,
RUSSIAN FEDERATION
Fax: +70959516943
E-mail: novikov@minatom.ru

Novikov, S.V.
Ministry of Foreign Affairs of the Russian Federation,
Smolenskaya Sennaya 32/34,
RU-121200 Moscow,
RUSSIAN FEDERATION
E-mail: s_newman@mail.ru

Pavlovsky, O.A.
Nuclear Safety Institute (IBRAE),
Russian Academy of Sciences,
52 Bolshaya Tulskaya Street,
RU-113191 Moscow,
RUSSIAN FEDERATION
Fax: +70959580080
E-mail: pavl@ibrae.ac.ru

Platov, A.I.
Russian National Technical Physics
and Automation Research Institute,
Minatom,
Varshavskoye Shosse 46,
RU-115230 Moscow,
RUSSIAN FEDERATION
Fax: +70951115434

Rumyantsev, A.Y.
Ministry of the Russian Federation for
Atomic Energy (Minatom),
24/26 Bolshaya Ordynka,
RU-109180 Moscow,
RUSSIAN FEDERATION
Fax: +70952302420

Rybachenkov, V.
Ministry of Foreign Affairs of the Russian Federation,
Smolenskaya Sennaya 32/34,
RU-121200 Moscow,
RUSSIAN FEDERATION

Ryzhov, M.N.
Ministry of the Russian Federation for
Atomic Energy (Minatom),
24/26 Bolshaya Ordynka,
RU-109180 Moscow,
RUSSIAN FEDERATION
Fax: +70952302420

Shatalov, V.
All-Russian Scientific Research Institute of Chemical Technology,
Kashirskoe Shosse 33,
RU-103001 Moscow,
RUSSIAN FEDERATION
Fax: +70953245441
E-mail: shatalov@vniiht.ru

Shingarev, N.E.
Ministry of the Russian Federation for Atomic Energy (Minatom),
24/26 Bolshaya Ordynka,
RU-109180 Moscow,
RUSSIAN FEDERATION
Fax: +7092302535

Sitnikov, S.A.
Federal Nuclear and Radiation Safety Authority of the Russian Federation (Gosatomnadzor),
Taganskaya Street 34,
RU-109147 Moscow,
RUSSIAN FEDERATION
Fax: +70959116077
E-mail: ssa@gan.ru

Tarkhanova, O.E.
Parliament of the Russian Federation,
State Duma,
Okhotny Ryad 1,
RU-103265 Moscow,
RUSSIAN FEDERATION
Fax: +70952928932

Ubeev, A.
Permanent Mission of the Russian Federation to the International Atomic Energy Agency,
Erzherzog-Karl-Strasse 182,
A-1220 Vienna,
AUSTRIA
Fax: +4312805687

Vaganov, A.
Nezavisimaya Gazeta Editorial Office,
Myasnitskaya 13,
RU-101000 Moscow,
RUSSIAN FEDERATION
Fax: +70959752346

Vovk, N.V.
Ministry of the Russian Federation for Atomic Energy (Minatom),
24/26 Bolshaya Ordynka,
RU-109180 Moscow,
RUSSIAN FEDERATION
Fax: +70952302420

Zbaratskaya, M.V.
Ministry of the Russian Federation for Atomic Energy (Minatom),
24/26 Bolshaya Ordynka,
RU-109180 Moscow,
RUSSIAN FEDERATION
Fax: +70952302420

Zemsky, S.
Permanent Mission of the Russian Federation to the International Atomic Energy Agency,
Erzherzog-Karl-Strasse 182,
A-1220 Vienna,
AUSTRIA
Fax: +4312805687

SAUDI ARABIA

Al-Athel, S.A.
King Abdulaziz City for Science and Technology (KACST),
P.O. Box 6086,
KSA-Riyadh 11442,
SAUDI ARABIA
Fax: +96614883756
E-mail: athel@tecst.ebu.se

Al-Sulaiman, K.M.
Institute of Atomic Energy Research,
King Abdulaziz City for Science and Technology (KACST),
P.O. Box 6086,
KSA-Riyadh 11442,
SAUDI ARABIA
Fax: +96614883756

Al-Taifi, I.M.
Permanent Mission of the Kingdom of Saudi Arabia to the International Atomic Energy Agency,
Formanekgasse 38,
A-1190 Vienna,
AUSTRIA
Fax: +4313672540
E-mail: emb.saudiarabia.vienna@aon.at

Al-Twaijri, A. Ministry of Defense and Aviation,
Riyadh,
SAUDI ARABIA

Kurdi, O.M. Permanent Mission of the Kingdom of Saudi Arabia
to the International Atomic Energy Agency,
Formanekgasse 38,
A-1190 Vienna,
AUSTRIA
Fax: +4313672540
E-mail: emb.saudiarabia.vienna@aon.at

Sendi, M.A. Permanent Mission of the Kingdom of Saudi Arabia
to the International Atomic Energy Agency,
Formanekgasse 38,
A-1190 Vienna,
AUSTRIA
Fax: +4313672540
E-mail: viennaofficekacst@aon.at

SERBIA AND MONTENEGRO

Cekic, J. Permanent Mission of Serbia and Montenegro
to the International Atomic Energy Agency,
Rennweg 3,
A-1030 Vienna,
AUSTRIA
Fax: +4317132597

Domazet, D. Ministry of Science, Technology and Development
of the Republic of Serbia,
Nemanjina 22–24,
11000 Belgrade,
SERBIA AND MONTENEGRO
Fax: +38111688047
E-mail: ddomazet@mnt.bg.ac.yu

Kolundzija, V. Federal Ministry of Economy and Internal Trade,
Bulevar Mihajla Pupina 1,
11070 Belgrade,
SERBIA AND MONTENEGRO
Fax: +38111142088
E-mail: stan.k@eunet.yu or vesnak@smput.sv.gov.yu

Milinkovic, B.
Permanent Mission of Serbia and Montenegro to the International Atomic Energy Agency,
Rennweg 3,
A-1030 Vienna,
AUSTRIA
Fax: +4317132597

Nikcevic, M.
Border and Foreign Department,
Ministry of Internal Affairs of the Republic of Montenegro,
Bulevar Lenjina 6,
Podgorica,
SERBIA AND MONTENEGRO
Fax: +38181225618
E-mail: nikcevic@cg.yu

Sparic, M.
Border and Foreign Department,
Ministry of Internal Affairs of the Republic of Serbia,
Bulevar AVNOJ/a 104,
11070 Belgrade,
SERBIA AND MONTENEGRO
Fax: +381113118895

Vukicevic, D.
Federal Ministry of Economy and Internal Trade,
Bulevar Mihajla Pupina 1,
11070 Belgrade,
SERBIA AND MONTENEGRO
Fax: +38111142088

SIERRA LEONE

Kongo, J.J.
Ministry of Energy and Power,
Electricity House,
Siaka Stevens Street,
Freetown,
SIERRA LEONE
Fax: +23222224527

SINGAPORE

Chong Ket Min, S.
Centre for Radiation Protection,
Health Sciences Authority,
11 Outram Road,
Singapore 169078,
SINGAPORE
Fax: +6562262353
E-mail: Stephen_Chong@hsa.gov.sg

SLOVAKIA

Adámek, P.	Radiation Protection Department, State Institute of Public Health, Cesta K Nemocnici 1, SK-975 56 Banska Bystrica, SLOVAKIA Fax: +421484142501 E-mail: adamek@szubb.sk
Auxtová, L.	Radiation Protection Department, State Institute of Public Health, Cesta K Nemocnici 1, SK-975 56 Banska Bystrica, SLOVAKIA Fax: +421484142501 E-mail: auxtova@szubb.sk
Bindová, L.	Permanent Mission of the Slovak Republic to the International Atomic Energy Agency, Blaasstrasse 34, A-1190 Vienna, AUSTRIA Fax: +4313689433222
Kopecka, J.	Ministry of Interior, Racianska 45, SK-812 72 Bratislava, SLOVAKIA Fax: +42196105904
Nemethy, A.	Permanent Mission of the Slovak Republic to the International Atomic Energy Agency, Blaasstrasse 34, A-1190 Vienna, AUSTRIA Fax: +4313689433222
Vaclav, J.	Nuclear Regulatory Authority, Okruzna 5, SK-918 64 Trnava, SLOVAKIA Fax: +421335991190 E-mail: juraj.vaclav@ujd.gov.sk

SLOVENIA

Cesarek, J. — Slovenian Nuclear Safety Administration (SNSA),
P.O. Box 5759,
Zelezna cesta 16,
SL-1001 Ljubljana,
SLOVENIA
Fax: +38614721199
E-mail: janez.cesarek@gov.si

Kovse, R. — Criminal Investigation Directorate,
Stefanova ulica 2,
SL-1000 Ljubljana,
SLOVENIA
Fax: +38615272312
E-mail: Robert.kovse@policija.si

SOUTH AFRICA

Kotzé, T.C. — Radiation Control, Department of Health,
Private Bag X62,
7535 Bellville,
SOUTH AFRICA
Fax: +27219461589
E-mail: tobiek@health.gov.za

Moleah, A.T. — Permanent Mission of South Africa
to the International Atomic Energy Agency,
Sandgasse 33,
A-1190 Vienna,
AUSTRIA
Fax: +431 320649351
E-mail: saembvie@aon.at

Monale, P.E. — Department of Minerals and Energy,
Private Bag X59,
0001 Pretoria,
SOUTH AFRICA
Fax: +27123275224
E-mail: elsiem@mepta.pwv.gov.za

Pretorius, G.F.A. — National Nuclear Regulator,
P.O. Box 7106,
0046 Centurion,
SOUTH AFRICA
Fax: +27126747164
E-mail: bpretori@nnr.co.za

Schoombie, N.S. Permanent Mission of South Africa
to the International Atomic Energy Agency,
Sandgasse 33,
A-1190 Vienna,
AUSTRIA
Fax: +431320649351
E-mail: saembvie@aon.at

Thema, M.P. Permanent Mission of South Africa
to the International Atomic Energy Agency,
Sandgasse 33,
A-1190 Vienna,
AUSTRIA
Fax: +4313207584
E-mail: saembvie@aon.at

Zondo, L. National Nuclear Regulator,
P.O. Box 7106,
0046 Centurion,
SOUTH AFRICA
Fax: +27126747822
E-mail: lzondo@nnr.co.za

SPAIN

Estevan Bolea, M.T. Consejo de Seguridad Nuclear,
Justo Dorado 11,
E-28040 Madrid,
SPAIN
Fax: +34913460103
E-mail: mteb@csn.es

García Pérez, M.A. Consejo de Seguridad Nuclear,
Justo Dorado 11,
E-28040 Madrid,
SPAIN
Fax: +34913460103
E-mail: agp@csn.es

Gil López, E. Consejo de Seguridad Nuclear,
Justo Dorado 11,
E-28040 Madrid,
SPAIN
Fax: +34913460471
E-mail: egl@csn.es

Lira Calvo, J. | Comisaría General de Información,
Unidad Central de Información Exterior,
c/Julián González Segador s/n,
E-28043 Madrid,
SPAIN
Fax: +34915822070
E-mail: j.s4@policia.es

Recio, M. | Directorate-General for Energy Policy and Mines,
Ministry of Economy,
Paseo de la Castellana 160,
E-28046 Madrid,
SPAIN
Fax: +913497529
E-mail: MRecio@mineco.es

Rios Calvo, P. | Unidad Central de Desactivación de Explosivos y NBQ,
c/Julián González Segador s/n,
E-28043 Madrid,
SPAIN
Fax: +913881516
E-mail: pedro.rios@dgp.mir.es

Ruiz, J. | Permanent Mission of Spain to the International Atomic Energy Agency,
Gonzagagasse 15/2,
A-1010 Vienna,
AUSTRIA
Fax: +4315359887
E-mail: j.ruiz@spain-unov.org

Tormo, M. | Consejo de Seguridad Nuclear,
Justo Dorado 11,
E-28040 Madrid,
SPAIN
Fax: +34913460588
E-mail: mtf@csn.es

Torres Vidal, C. | Consejo de Seguridad Nuclear,
Justo Dorado 11,
E-28040 Madrid,
SPAIN
Fax: +34913460103
E-mail: ctv@csn.es

SRI LANKA

Anil Ranjith, H.L.
Atomic Energy Authority,
Baseline Road 60/460,
Orugodawatta,
Wellampitiya,
SRI LANKA
E-mail: srlaea@slt.lk

Siriwardhane, S.
Ministry of Defense,
National Authority for the Implementation of the Chemical Weapon Convention
Colombo,
SRI LANKA
Fax: +941541529
E-mail: fer426@mail.army.lk

SUDAN

El-Nour, F.
General Administration of Customs Police,
Khartoum,
SUDAN

Eltayeb, M.A.H.
Sudan Atomic Energy Commission,
P.O. Box 3001,
Khartoum,
SUDAN
Fax: +24911774179
E-mail: saec@sudanmail.net

SWEDEN

Andersson, S.
Swedish Nuclear Power Inspectorate (SKI),
Klarabergsviadukten 90,
SE-106 58 Stockholm,
SWEDEN
Fax: +4686619086
E-mail: sarmite.andersson@ski.se

Höglund, P.
Swedish Radiation Protection Authority,
Karolinska Institute,
SE-171 16 Stockholm,
SWEDEN
Fax: +4687297108
E-mail: erik.hoglund@ssi.se

Jörle, A. Swedish Nuclear Power Inspectorate (SKI),
Klarabergsviadukten 90,
SE-106 58 Stockholm,
SWEDEN
Fax: +4686619086
E-mail: anders.jorle@ski.se

Stålnacke, C.-G. Swedish Radiation Protection Authority,
Karolinska Institute,
SE-171 16 Stockholm,
SWEDEN
E-mail: carl-goran.stalnacke@ssi.se

Ulvsand, T. Division of NBC Defence,
Swedish Defence Research Agency,
SE-901 82 Umeå,
SWEDEN
Fax: +4690106800
E-mail: thomas.ulvsand@foi.se

Wredberg, L. Swedish Nuclear Power Inspectorate,
Hammerschmidtgasse 18/1,
A-1190 Vienna,
AUSTRIA
Fax: +4313707767
E-mail: lars.wredberg@chello.at

SWITZERLAND

Elmer, E. Division of Radiation Protection,
Federal Office of Public Health,
CH-3003 Bern,
SWITZERLAND
E-mail: ernst.elmer@bag.admin.ch

Kellenberger, M. Central Office for Nuclear Goods,
Service for Analysis and Prevention,
Federal Office of Police,
CH-3003 Bern,
SWITZERLAND
Fax: +41313247948
E-mail: markus.kellenberger@fedpol.ch

Luyet, G. Eidgenössische Zollverwaltung (EZV),
Monbijoustrasse 40,
CH-3003 Bern,
SWITZERLAND
Fax: +41313239279
E-mail: gerard.luyet@ezv.admin.ch

Rauber, D.F. Nationale Alarmzentrale,
Ackermannstrasse 26, Postfach,
CH-8044 Zurich,
SWITZERLAND
Fax: +4112569497
E-mail: ra@naz.ch

Wieland, B. Nuclear Energy Section,
Swiss Federal Office of Energy,
Worblentalstrasse 32,
CH-3003 Bern,
SWITZERLAND
Fax: +41313220078
E-mail: beat.wieland@bfe.admin.ch

SYRIAN ARAB REPUBLIC

Othman, I. Atomic Energy Commission of Syria (AECS),
P.O. Box 6091,
Damascus,
SYRIAN ARAB REPUBLIC
Fax: +963116112289
E-mail: atomic@aec.org.sy

TAJIKISTAN

Khikmatov, M. Nuclear and Radiation Safety Agency of the Academy of Sciences of Tajikistan,
33 Rudaki Avenue,
734025 Dushanbe,
TAJIKISTAN
Fax: +992372214911
E-mail: academy@science.tajik.net

Mirsaidov, U. | Nuclear and Radiation Safety Agency of the Academy of Sciences of Tajikistan,
33 Rudaki Avenue,
734025 Dushanbe,
TAJIKISTAN
Fax: +992372214911
E-mail: academy@science.tajik.net

Salomov, J.A. | Nuclear and Radiation Safety Agency of the Academy of Sciences of Tajikistan,
33 Rudaki Avenue,
734025 Dushanbe,
TAJIKISTAN
Fax: +992372214911
E-mail: academy@science.tajik.net

THAILAND

Aramrattana, M. | Office of Atomic Energy for Peace (OAEP),
16 Vibhavadi Rangsit Road,
Chatuchak,
Bangkok 10900,
THAILAND
Fax: +6625613013
E-mail: manoon@oaep.go.th

Punnachaiya, M. | Radioactive Waste Management Program,
Office of Atomic Energy for Peace (OAEP),
16 Vibhavadi Rangsit Road,
Chatuchak,
Bangkok 10900,
THAILAND
Fax: +6625613013
E-mail: monta@oaep.go.th

Wanitsuksombut, W. | Office of Atomic Energy for Peace (OAEP),
16 Vibhavadi Rangsit Road,
Chatuchak,
Bangkok 10900,
THAILAND
Fax: +6625613013
E-mail: waraponw@oaep.go.th or
waraponw@yahoo.com

THE FORMER YUGOSLAV REPUBLIC OF MACEDONIA

Kolev, N.
Permanent Mission of the Former Yugoslav Republic of Macedonia to the International Atomic Energy Agency,
Engelsberggasse 5/7,
A-1030 Vienna,
AUSTRIA
Fax: +4315248701
E-mail: mak.permanentmission@chello.at

Kuzevski, G.
Macedonian Customs Administration,
Lazar Licenovski 13,
1000 Skopje,
THE FORMER YUGOSLAV REPUBLIC OF MACEDONIA
Fax: +3892237832
E-mail: kuzevski@mt.net.mk

Mihajlovski, L.
Macedonian Customs Administration,
Lazar Licenovski 13,
1000 Skopje,
THE FORMER YUGOSLAV REPUBLIC OF MACEDONIA
Fax: +3892237832
E-mail: kuzevski@mt.net.mk

Tavciovski, A.
Permanent Mission of the Former Yugoslav Republic of Macedonia to the International Atomic Energy Agency,
Engelsberggasse 5/7,
A-1030 Vienna,
AUSTRIA
Fax: +4315248701
E-mail: mak.permanentmission@chello.at

TUNISIA

Chekir, R.
Centre national de radioprotection (CNRP),
Hôpital d’enfants,
Place Bab Saadoun,
1006 Tunis,
TUNISIA
Fax: +21671571697
E-mail: sadok.mtimet@rms.tn

TURKEY

Erpul, N.G.
Permanent Mission of Turkey
to the International Atomic Energy Agency,
Rennweg 17,
P.O. Box 13,
A-1030 Vienna,
AUSTRIA
Fax: +4317142099
E-mail: tpm@i-node.at

Güzel, M.
Directorate General of Customs Enforcement,
Gümrükler Muhafaza Genel,
Müdürlügü,
Anafartalar caddesi 6, Kat. 6,
Ulus, Ankara,
TURKEY
Fax: +903123068055
E-mail: mehmetg@gumruk.gov.tr

Koca, I.
Permanent Mission of Turkey
to the International Atomic Energy Agency,
Rennweg 17,
P.O. Box 13,
A-1030 Vienna,
AUSTRIA
Fax: +4317142099
E-mail: tpm@i-node.at

Önder, R.U.
Permanent Mission of Turkey
to the International Atomic Energy Agency,
Rennweg 17,
P.O. Box 13,
A-1030 Vienna,
AUSTRIA
Fax: +4317142099
E-mail: tpm@i-node.at

Sahinbas, A.
Permanent Mission of Turkey
to the International Atomic Energy Agency,
Rennweg 17,
P.O. Box 13,
A-1030 Vienna,
AUSTRIA
Fax: +4317142099
E-mail: tpm@i-node.at

Tomak, M.
Turkish Atomic Energy Authority,
Eskisehir Yolu,
TR-06530 Lodumlu, Ankara
TURKEY
Fax: +903122856776
E-mail: mehmet.tomak@taek.gov.tr

Uslu, I.
Radiological Health and Safety Department,
Turkish Atomic Energy Authority,
Eskisehir Yolu,
TR-06530 Lodumlu, Ankara
TURKEY
Fax: +903122854284
E-mail: ibrahim.uslu@taek.gov.tr

UGANDA

Byakagaba, A.
Uganda Police,
P.O. Box 573,
Kampala,
UGANDA
Fax: +25641251490
E-mail: abasbyakagaba@yahoo.com

Emaru, M.
Ministry of Energy and Mineral Development,
P.O. Box 7270,
Kampala,
UGANDA
Fax: +25641230220
E-mail: emarumac@africaonline.co.ug

UKRAINE

Chernykh, S.
Security Service of Ukraine,
33 Volodymyrska Street,
UA-01601 Kyiv 33,
UKRAINE

Gryshchenko, K.
State Nuclear Regulatory Committee of Ukraine,
9/11 Arsenalna,
UA-01011 Kyiv,
UKRAINE
Fax: +380442543311

Holubiev, V. | State Nuclear Regulatory Committee of Ukraine,
9/11 Arsenalna,
UA-01011 Kyiv,
UKRAINE
Fax: +380442543311
E-mail: holubiev@hq.snrc.gov.ua

Kondratov, S. | Center of Energy and Nuclear Law,
National Academy of Sciences of Ukraine,
29 Gorkogo Street,
UA-01033 Kyiv,
UKRAINE
Fax: +380442278478
E-mail: cenl@alfacom.net

Kosenko, V. | Ministry of Ukraine of Emergencies and
Affairs of Population Protection,
Kiprianova 4, Apr. 103,
UA-03146 Kyiv,
UKRAINE
Fax: +380442652767

Kryzhanivsky, V. | Permanent Mission of Ukraine
to the International Atomic Energy Agency,
Naaffgasse 23,
A-1180 Vienna,
AUSTRIA
Fax: +431479717247
E-mail: ukremb@netway.at

Mialnytsa, O. | Permanent Mission of Ukraine
to the International Atomic Energy Agency,
Naaffgasse 23,
A-1180 Vienna,
AUSTRIA
Fax: +431 479717247

Ohrysko, V. | Permanent Mission of Ukraine
to the International Atomic Energy Agency,
Naaffgasse 23,
A-1180 Vienna,
AUSTRIA
Fax: +431479717247

Polurez, Y. Permanent Mission of Ukraine
to the International Atomic Energy Agency,
Naaffgasse 23,
A-1180 Vienna,
AUSTRIA
Fax: +431479717247

Yermilov, S. Ministry of Fuel and Energy of Ukraine,
Khreshchatyk Street 30,
UA-01601 Kyiv-1,
UKRAINE

UNITED ARAB EMIRATES

Abdalla, S.S.M. Ministry of Electricity and Water,
P.O. Box 99979,
Dubai,
UNITED ARAB EMIRATES
Fax: +97142945005
E-mail: sshaheen@eim.ae

Al-Mazrooei, K.M.S. United Arab Emirates Armed Forces,
P.O. Box 11323,
Masafi Al Fujairah,
UNITED ARAB EMIRATES
Fax: +97192565770
E-mail: hy2uae@hotmail.com

Al Rashidi, S.H. United Arab Emirates Armed Forces,
P.O. Box 20840,
Al Ain,
UNITED ARAB EMIRATES
Fax: +97137833700

UNITED KINGDOM

Andrews, T.J. Permanent Mission of the United Kingdom of
Great Britain and Northern Ireland to the
International Atomic Energy Agency,
Jauresgasse 12,
A-1030 Vienna,
AUSTRIA
Fax: +431716134900
E-mail: tim.andrews@fco.gov.uk

Ashburn, D.I.	Enviros Consulting Ltd, 61 The Shore, Leith, Edinburgh EH6 6RA, UNITED KINGDOM Fax: +1315559515 E-mail: donald.ashburn@enviros.com
Croft, J.R.	Communications Department, National Radiological Protection Board, Chilton, Didcot, Oxfordshire OX11 0RQ, UNITED KINGDOM Fax: +441235822630 E-mail: john.croft@nrpb.org
Dawson, F.	Ministry of Defence, Room 213, St. Giles Court, 1–13 St. Giles High Street, London WC2H 8LD, UNITED KINGDOM E-mail: dsefpol-hdhp@defence.mod.uk
Griffiths, G.	Counter Terrorism Security, South Yorkshire Police, UNITED KINGDOM Fax: +441142523244 E-mail: Garry.Griffiths@southyoorks.pnn.poloce.uk
Holyoak, B.	Health and Safety Executive, Radiation Corporate Topic Group, Room 405, Magdalen House, Stanley Precinct, Bootle, Merseyside L20 3QZ, UNITED KINGDOM E-mail: b.holvoak@ntlworld.com
Howat, B.	National Counter Terrorism Security Office (NaCTSO), P.O. Box 849, London SW1P 1XD, UNITED KINGDOM Fax: +442076300143 E-mail: nactso@btopenworld.com

Husher, A.F.	National Counter Terrorism Security Office (NaCTSO), P.O. Box 849, London SW1P 1XD, UNITED KINGDOM Fax: +442076300143 E-mail: nactso@btopenworld.com
Jenkins, P.R.	Permanent Mission of the United Kingdom of Great Britain and Northern Ireland to the International Atomic Energy Agency, Jauresgasse 12, A-1030 Vienna, AUSTRIA Fax: +431716134237 E-mail: Peter.Jenkins@fco.gov.uk
Marriott, J.	Nuclear Policy, Non-Proliferation Department, Foreign and Commonwealth Office, Downing Street West, London SW1A 2AH, UNITED KINGDOM E-mail: Jane.Marriott@fco.gov.uk
Price, C.	Office for Civil Nuclear Security (OCNS), Department of Trade and Industry, B146 Harwell, Didcot, Oxfordshire OX11 0RA, UNITED KINGDOM Fax: +441235432927 E-mail: chris.price@ocns.gsi.gov.uk
Russ, R.M.	Environment Agency, Block 1, Government Buildings, Burghill Road, Westbury-on-Trym, Bristol BS10 6BF, UNITED KINGDOM E-mail: bob.russ@environment-agency.gov.uk

Twomey, T.R.
Astro House,
Brants Bridge,
Bracknell, Berkshire RG12 9HW,
UNITED KINGDOM
Fax: +441189714672
E-mail: tim.twomey@ortec-online.com

Wager, K.
Nuclear Industries Directorate,
Department of Trade and Industry,
Room 194,
1 Victoria Street,
London SW1H 0ET,
UNITED KINGDOM
Fax: +442072152841
E-mail: kim.wager@dti.gsi.gov.uk

Whitby, B.
Permanent Mission of the United Kingdom of Great Britain and Northern Ireland to the International Atomic Energy Agency,
Jauresgasse 12,
A-1030 Vienna,
AUSTRIA
Fax: +431716134900
E-mail: ben.whiteby@fco.gov.uk

UNITED REPUBLIC OF TANZANIA

Banzi, F.P.
National Radiation Commission,
P.O. Box 743,
Arusha,
UNITED REPUBLIC OF TANZANIA
Fax: +255272509709
E-mail: banzi65@hotmail.com

Nyanda, A.M.
National Radiation Commission,
P.O. Box 743,
Arusha,
UNITED REPUBLIC OF TANZANIA
Fax: +255272509709
E-mail: nrctz@habari.co.tz

UNITED STATES OF AMERICA

Abraham, S.	United States Department of Energy, 1000 Independence Avenue, SW, Washington, DC 20585, UNITED STATES OF AMERICA Fax: +12025864403 E-mail: the.secretary@hq.doe.gov
Allen, R.W.	Lawrence Livermore National Laboratory, 7000 East Avenue, Livermore, CA 94550, UNITED STATES OF AMERICA Fax: +9254236787 E-mail: allen17@llnl.gov
Aloise, E.E.	United States General Accounting Office, 441 G Street, NW, Washington, DC 20548, UNITED STATES OF AMERICA Fax: +12625126880 E-mail: aloisee@gao.gov
Altman, S.M.	Nuclear Treaty Programs Office, United States Department of Defense, 1515 Wilson Boulevard, Suite 720, Arlington, VA 22209, UNITED STATES OF AMERICA Fax: +17035881984 E-mail: stuart.altman@osd.mil
Anderson Bailey, V.	United States Department of Energy, 1000 Independence Avenue, SW, Washington, DC 20585, UNITED STATES OF AMERICA
Augustine, P.K.	Permanent Mission of the United States of America to the International Atomic Energy Agency, Wagramer Strasse 17–19, A-1220 Vienna, AUSTRIA Fax: +4313698392 E-mail: augustinepk@state.gov

Awan, R.	Embassy of the United States of America, 5850 Kyiv Place, Kyiv, UKRAINE Fax: +380448447350 E-mail: awanrx@state.gov
Baker, K.	National Nuclear Security Agency, United States Department of Energy, 1000 Independence Avenue, SW, Washington, DC 20585, UNITED STATES OF AMERICA Fax: +12025860862 E-mail: ken.baker@hq.doe.gov
Blaha, J.L.	Permanent Mission of the United States of America to the International Atomic Energy Agency, Wagramer Strasse 17–19, A-1220 Vienna, AUSTRIA Fax: +431313394775 E-mail: BlahaJL@state.gov
Blumenthal, D.J.	United States European Command, HQ USEUCOM/EC-J36, Unit 30400, APO AE 09131, Plieninger Strasse 260, D-70567 Stuttgart, GERMANY Fax: +49711726729 E-mail: daniel.blumenthal@cmtymail.6asg.army.mil
Bolton, C.	United States Department of Energy, 1000 Independence Avenue, SW, Washington, DC 20585, UNITED STATES OF AMERICA Fax: +12025863617 E-mail: charles.bolton@nnsa.doe.gov

Bradley, L.E.
United States European Command,
HQ USEUCOM/EC-J36, Unit 30400,
APO AE 09131,
Plieninger Strasse 260,
D-70567 Stuttgart,
GERMANY
Fax: +49711726729
E-mail: leo.bradley@us.army.mil or
leo.bradley@cmtymail.6asg.army.mil

Brill, K.C.
Permanent Mission of the United States of America to the International Atomic Energy Agency,
Wagramer Strasse 17–19,
A-1220 Vienna,
AUSTRIA
Fax: +431313394871
E-mail: kenbrill@state.gov

Brooks, L.F.
United States Department of Energy,
1000 Independence Avenue, SW,
Washington, DC 20585,
UNITED STATES OF AMERICA
Fax: +12025864892
E-mail: linton.brookhq.doe.gov

Burns, P.C.
International Operations,
Office of Maritime and Land Security,
Transportation Security Administration,
400 Seventh Street, SW,
Washington, DC 20590,
UNITED STATES OF AMERICA
Fax: +15712271632
E-mail: partick.burns@tsa.dot.gov

Chamberlain, D.B.
Argonne National Laboratory,
9700 South Cass Avenue,
Building 205, C251,
Argonne, IL 60439-4833,
UNITED STATES OF AMERICA
Fax: +16309724409
E-mail: chamberlain@cmt.anl.gov

Chapek, J.
Sandia National Laboratories,
P.O. Box 5800,
Albuquerque, NM 87185,
UNITED STATES OF AMERICA
Fax: +15058446067
E-mail: jfchape@sandia.gov

Cherry, R.
International Safeguards,
United States Department of Energy,
1000 Independence Avenue, SW,
Washington, DC 20585,
UNITED STATES OF AMERICA
Fax: +12025860936
E-mail: ron.cherry@hq.doe.gov

Coleman, J.T.
United States Department of Energy,
Savannah River Technology Center,
Building 773-A,
Aiken, SC 29808,
UNITED STATES OF AMERICA
Fax: +18037254581
E-mail: jerry.coleman@srs.gov

Cutler, K.B.
United States Department of State,
2201 C Street, NW,
Washington, DC 20520,
UNITED STATES OF AMERICA
Fax: +12026470937
E-mail: Cutlerkb@t.state.gov

Daitch, W.B.
United States Defense Threat Reduction Agency,
8725 John J. Kingman Road,
Mail Stop 6201,
Fort Belvoir, VA 22060-6201,
UNITED STATES OF AMERICA
Fax: +7033254661
E-mail: william.daitch@dtra.mil

Dandy, M.
United States Department of Energy,
1000 Independence Avenue, SW, S-1,
Washington, DC 20585,
UNITED STATES OF AMERICA
Fax: +12025867210
E-mail: majida.dandy@hq.doe.gov

Dash, M.S.
United States Department of Energy,
1000 Independence Avenue, SW,
Washington, DC 20585,
UNITED STATES OF AMERICA
Fax: +12025860862
E-mail: michele.dash@nnsa.doe.gov

Davis, J.H.
United States Department of Energy,
1000 Independence Avenue, SW,
Washington, DC 20585,
UNITED STATES OF AMERICA
Fax: +12025869987
E-mail: joseph.davis@hq.doe.gov

Dempsey, G.D.
Radiation and Indoor Environments National Laboratory,
United States Environmental Protection Agency,
P.O. Box 98517,
Las Vegas, NV 89193,
UNITED STATES OF AMERICA
Fax: +17027982465
E-mail: harrison.jed@epa.gov

Desmond, W.J.
United States Nuclear Regulatory Commission (USNRC),
Mail Stop T4 D8,
Washington, DC 20555-0001,
UNITED STATES OF AMERICA
Fax: +13014156661
E-mail: wjd2@nrc.gov

Dicus, G.J.
United States Nuclear Regulatory Commission (USNRC),
OWFN Building,
Mail Stop 16 C1,
Washington, DC 20555-0001,
UNITED STATES OF AMERICA A
Fax: +13014153504
E-mail: cmrdicus@nrc.gov

Dodd, L.
Idaho National Engineering Laboratory,
Building EROB, Room 306,
Mail Stop 3855,
Idaho Falls, ID 83415,
UNITED STATES OF AMERICA
Fax: +12085264311
E-mail: doddLR@inel.gov

Dunn Lee, J. | United States Nuclear Regulatory Commission (USNRC),
Washington, DC 20555,
UNITED STATES OF AMERICA
Fax: +13014152400
E-mail: jdl@nrc.gov

Ferguson, C.D. | Monterey Institute of International Studies,
11 Dupont Circle, NW, 9th Floor,
Washington, DC 20036,
UNITED STATES OF AMERICA
Fax: +12022389603
E-mail: charles.ferguson@miis.edu

Foster, J.L. | Transportation Security Administration,
601 South 12th Street, 10th Floor,
Arlington, VA 22202,
UNITED STATES OF AMERICA
E-mail: joefoster@tsa.dot.gov

Frant, S.M. | United States Nuclear Regulatory Commission (USNRC),
Mail Stop T8 P5,
Washington, DC 20555,
UNITED STATES OF AMERICA
Fax: +3014155369
E-mail: sfs@nrc.gov

Freier, K. | Pacific Northwest National Laboratory,
P.O. Box 999,
Richland, WA 99352,
UNITED STATES OF AMERICA
Fax: +15093752766
E-mail: keith.freier@pnl.gov

Garner, K. | United States Department of Energy,
1000 Independence Avenue, SW, NA-25,
Washington, DC 20585,
UNITED STATES OF AMERICA
Fax: +12025863617
E-mail: kate.garner@nnsa.doe.gov

Goldberg, S.A.
New Brunswick Laboratory,
United States Department of Energy,
9800 South Cass Avenue,
Building 350,
Argonne, IL 60439,
UNITED STATES OF AMERICA
Fax: +16302526256
E-mail: steven.goldberg@ch.doe.gov

Goldman, I.
Permanent Mission of the United States of America to the International Atomic Energy Agency,
Wagramer Strasse 17–19,
A-1220 Vienna,
AUSTRIA
Fax: +4313698392
E-mail: igoldman@usia.co.at

Hanley, C.J.
International Desk,
The Associated Press,
50 Rockefeller Plaza,
New York, NY 10020,
UNITED STATES OF AMERICA A
Fax: +12126215449
E-mail: chanley@ap.org

Hart, S.M.
United States Department of State,
2201 C Street, NW,
Washington, DC 20520,
UNITED STATES OF AMERICA
Fax: +2027364336
E-mail: hartsm@T.state.gov

Heard, P.S.
United States General Accounting Office,
441 G Street, NW, 2T23A,
Washington, DC 20548,
UNITED STATES OF AMERICA
Fax: +2025126880
E-mail: heardp@gao.gov

Hilliard, L.
Permanent Mission of the United States of America to the International Atomic Energy Agency,
Wagramer Strasse 17–19,
A-1220 Vienna,
AUSTRIA
Fax: +4313698392
E-mail: doe1@usia.co.at

Hudome, R. United States Department of Energy,
1000 Independence Avenue, SW, S-1,
Washington, DC 20585,
UNITED STATES OF AMERICA
Fax: +12025860148
E-mail: randa.hudome@hq.doe.gov

Huizenga, D. Office of Nuclear Safety and Cooperation,
National Nuclear Security Administration,
United States Department of Energy,
1000 Independence Avenue, SW,
Washington, DC 20585-001,
UNITED STATES OF AMERICA
Fax: +12025868171
E-mail: david.huizenga@nnsa.doe.gov

Iliopulos, I. United States Department of Energy,
1000 Independence Avenue, SW, NA-25,
Washington, DC 20585,
UNITED STATES OF AMERICA
Fax: +12025863617
E-mail: ionna.iliopulus@nnsa.doe.gov

Indusi, J.P. Non-Proliferation and National Security Department,
Brookhaven National Laboratory,
Building 197C,
P.O. Box 5000,
Upton, NY 11973,
UNITED STATES OF AMERICA
Fax: +16313447566
E-mail: indusi@bnl.gov

Johnson, C. United States Department of Energy,
1000 Independence Ave, SW, NA-25,
Washington, DC 20585,
UNITED STATES OF AMERICA
Fax: +12025863617
E-mail: craig.johnson@nnsa.doe.gov

Jonas, D.S. United States Department of Energy,
1000 Independence Avenue, SW,
Room GA-155/NA-31,
Washington, DC 20585,
UNITED STATES OF AMERICA
Fax: +12025867585
E-mail: dave.jonas@nnsa.doe.gov

Kohnen, A.
United States Department of Energy,
1000 Independence Avenue, SW, NA-25,
Washington, DC 20585,
UNITED STATES OF AMERICA
Fax: +12025863617
E-mail: anne.kohnen@nnsa.doe.gov

Kopsick, D.A.
Office of Radiation and Indoor Air,
United States Environmental Protection Agency,
41200 Pennsylvania Avenue, NW (6608J),
Washington, DC 20460,
UNITED STATES OF AMERICA
Fax: +12025652037
E-mail: kopsick.deborah@epa.gov

Levis, G.S.
United States General Accounting Office,
441 G Street, Room 2T23A,
Washington, DC 20548,
UNITED STATES OF AMERICA
Fax: +12025126880
E-mail: levisg@gao.gov

Lieberman, J.
United States Department of Energy,
1000 Independence Avenue, SW, NA-25,
Washington, DC 20585,
UNITED STATES OF AMERICA
E-mail: JBLI@nrc.gov

Linde, D.L.
Embassy of the United States of America,
Bolshoy Devyatinsky Pereulok 8,
RU-121099 Moscow ,
RUSSIAN FEDERATION
Fax: +70957285033
E-mail: lindedl@state.gov

Longsworth, P.M.
United States Department of Energy,
1000 Independence Avenue, SW,
Washington, DC 20585,
UNITED STATES OF AMERICA
Fax: +12025860148
E-mail: paul.longsworth@hq.doe.gov

Lopatto, J. | United States Department of Energy,
1000 Independence Avenue, SW, PA-1,
Washington, DC 20585,
UNITED STATES OF AMERICA
Fax: +12025869987
E-mail: jeanne.lopatto@hq.doe.gov

Lubenau, J.O. | 89 South Heck Road,
Littz, PA 17543-8560,
UNITED STATES OF AMERICA
Fax: +7176250436
E-mail: lubenau@supernet.com

Luna, R.E. | 10025 Barrinson NE,
Albuquerque, NM 87111,
UNITED STATES OF AMERICA
Fax: +15058580764
E-mail: lunar@asme.org

Mallin, M. | United States Department of Energy,
1000 Independence Avenue, SW, NA-20,
Washington, DC 20585,
UNITED STATES OF AMERICA
Fax: +12025860862
E-mail: monte.mallin@nnsa.doe.gov

Martin, C.R. | Nonprofileration Office of Nuclear Energy Affairs,
United States Department of State,
2201 C Street, NW,
Room 3318,
Washington, DC 20521,
UNITED STATES OF AMERICA
Fax: +12026470775
E-mail: martincd@t.state.gov

Martin, D. | United States Department of Energy,
1000 Independence Avenue, SW, NN-50,
Washington, DC 20585,
UNITED STATES OF AMERICA
Fax: +12025961348
E-mail: david.martin@hq.doe.gov

Mathews, J.
United States Customs Service,
1300 Pennsylvania Avenue, NW,
Washington, DC 20229,
UNITED STATES OF AMERICA
Fax: +12029275506
E-mail: Julia.mathews@customs.treas.gov

McClelland, V.
United States Department of Energy,
1000 Independence Avenue, SW, NA-23,
Washington, DC 20585,
UNITED STATES OF AMERICA
Fax: +12025868272
E-mail: vince.mcclelland@nnsa.doe.gov

McConnell, K.I.
United States Nuclear Regulatory Commission (USNRC),
11555 Rockville Pike,
Rockville, MD 20852,
UNITED STATES OF AMERICA
Fax: +3014151757
E-mail: kim@nrc.gov

McMonigle, J.
United States Department of Energy,
1000 Independence Avenue, SW,
Washington, DC 20585,
UNITED STATES OF AMERICA
E-mail: joe.mcmonigle@hq.doe.gov

Meserve, R.A.
United States Nuclear Regulatory Commission (USNRC),
11555 Rockville Pike,
Rockville, MD 20852,
UNITED STATES OF AMERICA
Fax: +13014151757
E-mail: ram@nrc.gov

Morrell, P.C.
United States Department of Energy,
1000 Independence Avenue, SW,
Washington, DC 20585,
UNITED STATES OF AMERICA
Fax: +12025860148

E-mail: paul.morrell@hq.doe.gov

Noble, S.V.
Permanent Mission of the United States of America
to the International Atomic Energy Agency,
Wagramer Strasse 17–19,
A-1220 Vienna,
AUSTRIA
Fax: +431313394873
E-mail: Noblesv2@state.gov

Paperiello, C.
United States Nuclear Regulatory Commission
(USNRC),
Mail Stop 16 E15,
Washington, DC 20555,
UNITED STATES OF AMERICA
Fax: +13014152700
E-mail: cjp1@nrc.gov

Rahaman, A.
United States Embassy,
3 Xiu Shui Bei Jii,
Bejing 100600,
CHINA
Fax: +861065323297
E-mail: rahamanaa@state.gov

Rapuano, K.
United States Department of Energy,
1000 Independence Avenue, SW,
Washington, DC 20585,
UNITED STATES OF AMERICA
Fax: +12025860148
E-mail: kenneth.rapuano@hq.doe.gov

Richardson, J.
Lawrence Livermore National Laboratory,
P.O. Box 808,
Livermore, CA 94550,
UNITED STATES OF AMERICA
Fax: +19254226434
E-mail: richardson6@llnl.gov

Satkowiak, L.
Oak Ridge National Laboratory,
1099 Commerce Park,
Oak Ridge, TN 37830,
UNITED STATES OF AMERICA
Fax: +18655743900

	E-mail: satkowiaklj@ornl.gov
Schoeneck, J.D.	United States Department of State, 2201 C Street, NW, Washington, DC 20520, UNITED STATES OF AMERICA Fax: +12027364336
Solich, D.J.	United States Department of Energy, SO-11/Germantown Building, 1000 Independence Avenue, SW, Washington, DC 20585-1290, UNITED STATES OF AMERICA Fax: +13019036961 E-mail: donald.solich@hq.doe.gov
Spitskaya, E.V.	United States Department of Energy, DOE Moscow Office, Bolshoy Devyatinsky Pereulok 8, RU-121099 Moscow, RUSSIAN FEDERATION Fax: +70957285360 E-mail: espitskaya@doe.ru
Stafford, M.	Office of Proliferation Threat Reduction, Bureau of Nonproliferation, United States Department of State, 2201 C Street, NW, Washington, DC 20520, UNITED STATES OF AMERICA Fax: +12027367698 E-mail: staffordmi@t.state.gov
Stillinger, C.D.	United States Department of Homeland Security, NNSA/NA-25, 1000 Independence Avenue, SW, Washington, DC 20585, UNITED STATES OF AMERICA Fax: +12025962572 E-mail: cara.stillinger@hq.doe.gov
Stratford, R.	United States Department of State, 2201 C Street, NW, NP/NE, Room 3320A, Washington, DC 20520, UNITED STATES OF AMERICA Fax: +12026470775

E-mail: stratfordrjk@t.state.gov

Swartz, R. — United States Department of Energy,
1000 Independence Avenue, SW, IN-1,
Washington, DC 20585,
UNITED STATES OF AMERICA
Fax: +12025860751
E-mail: bob.swartz@nnsa.doe.gov

Thomas, L.A. — United States Department of Agriculture,
901 D Street, SW,
Aerospace Building, 3rd Floor,
Washington, DC 20024,
UNITED STATES OF AMERICA
Fax: +43172777199
E-mail: lori.thomas@fsis.usda,gov

Tittemore, G. — United States Department of Energy,
1000 Independence Avenue, SW, NA-25,
Washington, DC 20585,
UNITED STATES OF AMERICA
Fax: +12025863617
E-mail: garry.tittemore@nnsa.doe.gov

Tschiltz, M.D. — United States Nuclear Regulatory Commission (USNRC),
11555 Rockville Pike,
Rockville, MD 20852,
UNITED STATES OF AMERICA
Fax: +13014151757
E-mail: mdt@nrc.gov

Uchida, K. — United States Department of Energy,
DOE Tokyo Office,
Tokyo,
JAPAN

Van Tuyle, G. — Los Alamos National Laboratory,
Mail Stop K760,
Los Alamos, NM 87545,
UNITED STATES OF AMERICA
Fax: +15056670966
E-mail: vantuyle@lanl.gov

Venkayya, R.

White House Fellow,
United States Department of Energy,
1000 Independence Avenue, SW,
Washington, DC 20585,
UNITED STATES OF AMERICA
Fax: +12026010586
E-mail: rajeev.venkayya@eh.doe.gov

Walker, S.

Argonne National Laboratory,
9700 South Cass Avenue,
Building 202,
Argonne, IL 60439-4833,
UNITED STATES OF AMERICA
Fax: +16302523847
E-mail: sewalker@anl.gov

Walkin, K.

United States Department of State,
2201 C Street, NW,
Room 5333,
Washington, DC 20520,
UNITED STATES OF AMERICA
Fax: +12027368902
E-mail: walking@state.gov

Wilkes, B.K.

United States Department of Energy,
1000 Independence Avenue, SW,
Washington, DC 20585,
UNITED STATES OF AMERICA
Fax: +12025863929
E-mail: bryan.wilkes@nnsa.doe.gov

Wishard, B.E.

United States Department of State,
2201 C Street, NW,
Washington, DC 20520,
UNITED STATES OF AMERICA

Zimmerman, P.D.

United States Senate Foreign Relations Committee,
United States National Defense University,
Center for Science, Technology and National Security,
10125 Nedra Drive,
Great Falls, VA 22066,
UNITED STATES OF AMERICA
Fax: +7037590507

E-mail: peterz@erols.com

URUGUAY

Alvarez Goyoaga, G.A.
Permanent Mission of Uruguay to the International Atomic Energy Agency,
Wallnerstrasse 4, Top NA 17,
A-1010 Vienna,
AUSTRIA
Fax: +4315356618

Borges Fernández, E.
Permanent Mission of Uruguay to the International Atomic Energy Agency,
Wallnerstrasse 4, Top NA 17,
A-1010 Vienna,
AUSTRIA
Fax: +4315356618

Nader, A.
National Direction of Nuclear Technology (DINATEN),
Minstry of Industry and Mines,
Mercedes 1041,
11100 Montevideo,
URUGUAY
Fax: +59829086783
E-mail: dinaten@hotmail.com

Yavarone, R.L.
Ministry of National Defense,
8 de Octubre 2628,
11600 Montevideo,
URUGUAY
Fax: +59824814833
E-mail: mdnssec@adinet.com.uy

UZBEKISTAN

Halilov, H.
Agency on Safety in Industry and Mining of the Republic of Uzbekistan,
C-14, Navoi Steet 27,
700011 Tashkent,
UZBEKISTAN
Fax: +998711442104
E-mail: hasan@tkt.uz

Tashmukhamedov, F. Agency on Safety in Industry and Mining
of the Republic of Uzbekistan,
C-14, Navoi Steet 27,
700011 Tashkent,
UZBEKISTAN
Fax: +988711442104
E-mail: hasan@tkt.uz

VENEZUELA

Manzanares, V. Permanent Mission of Venezuela to the
International Atomic Energy Agency,
Marokkanergasse 22/4,
A-1030 Vienna,
AUSTRIA
Fax: 4317153219
E-mail: emba.vene.austria@chello.at

VIETNAM

Dang Thanh Luong Vietnam Radiation Protection and
Nuclear Safety Authority,
59 Ly Thuong Kiet,
Hanoi,
VIETNAM
Fax: +8448220298 or +8449424133
E-mail: dtluong@moste.gov.vn

Lai Ngoc Doan Permanent Mission of Vietnam
to the International Atomic Energy Agency,
Felix-Mottl-Strasse 20,
A-1190 Vienna,
AUSTRIA
Fax: +4313680754

Tran Son Lam Science and Education Department of the
Government of Vietnam,
Hanoi,
VIETNAM
Fax: +848044130
E-mail: hq.vaeo@hn.vnn.vn

YEMEN

Bahran, M. — National Atomic Energy Commission (NATEC),
P.O. Box 4720,
Sana'a,
YEMEN
Fax: +9671259460

Noman, M. — National Atomic Energy Commission (NATEC),
P.O. Box 4720,
Sana'a,
YEMEN

ZAMBIA

Chunga, T.E. — Radiation Protection Board,
P.O. Box 474,
Lusaka,
ZAMBIA
Fax: +2601252481
E-mail: radiation@zamtel.zm

ZIMBABWE

Chikanda, V.A. — Permanent Mission of Zimbabwe
to the International Atomic Energy Agency,
Strozzigasse 10/15,
A-1080 Vienna,
AUSTRIA
Fax: +4314079238
E-mail: z.vien@chello.at

Kangai, T.J. — Permanent Mission of Zimbabwe
to the International Atomic Energy Agency,
Strozzigasse 10/15,
A-1080 Vienna,
AUSTRIA
Fax: +4314079238
E-mail: z.vien@chello.at

Mbizo, S. Hazardous Substances and Articles Unit,
Ministry of Health and Child Welfare,
P.O. Box CY 1122, Causeway,
Harare,
ZIMBABWE
Fax: +2634793634 or +2634702293
E-mail: stanmbizo@yahoo.co.uk

EUROPEAN COMMISSION

Byrne, A. Delegation of the European Commission to the IAEA,
Gusshausstrasse 8,
A-1040 Vienna,
AUSTRIA
Fax: +43150584117
E-mail: office@delaut.cec.eu.int

Daures, P. Institute for Transuranium Elements (JRC-ITE),
European Commission,
P.O. Box 2340,
D-76125 Karlsruhe,
GERMANY
Fax: +49724795199289
E-mail: daures@itu.fzk.de

De Esteban, F. Directorate General for Energy and Transport,
European Commission,
200 Rue de la Loi,
B-1049 Brussels,
BELGIUM
Fax: +3222950061

Pla, E.P.C. Directorate General for Energy and Transport,
European Commission,
24 Rue de Mot,
B-1040 Brussels,
BELGIUM
Fax: +3222950061
E-mail: enric.pla-campana@cec.eu.int

Tamborini, G. — Institute for Transuranium Elements (JRC-ITE),
European Commission,
P.O. Box 2340,
D-76125 Karlsruhe,
GERMANY
Fax: +497247951593
E-mail: tamborini@itu.fzk.de

Taylor, D.M. — Nuclear Safety, Regulation and
Radioactive Waste Management,
Directorate General for Energy and Transport,
European Commission,
200 Rue de la Loi,
B-1049 Brussels,
BELGIUM
Fax: +3222950061
E-mail: derek.taylor@cec.eu.int

EUROPEAN POLICE OFFICE (EUROPOL)

Gridling, P. — Organized Crime Department, S.C. 5,
Europol,
Raamweg 47,
P.O. Box 90850,
NL-2509 LW The Hague,
NETHERLANDS
Fax: +31703180843
E-mail: gridlingp@europol.eu.int

Zablot, F. — Organized Crime Department, S.C. 5,
Europol,
Raamweg 47,
P.O. Box 90850,
NL-2509 LW The Hague,
NETHERLANDS
Fax: +31703180843
E-mail: zablotf@europol.eu.int

INTERNATIONAL ATOMIC ENERGY AGENCY (IAEA)

Abedin-Zadeh, R.
Department of Safeguards,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: r.abedin-zadeh@iaea.org

Ali, Q.
Department of Nuclear Energy,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: q.ali@iaea.org

Al-Mughrabi, M.
Department of Nuclear Energy,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: m.al-mughrabi@iaea.org

Andrew, G.
Office of the Director General,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: g.andrew@iaea.org

Araj, K.J.
Office of Internal Oversight Services,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: k.j.araj@iaea.org

Arlt, R.D.	Department of Safeguards, International Atomic Energy Agency, Wagramer Strasse 5, P.O. Box 100, A-1400 Vienna, AUSTRIA Fax: +431260029317 E-mail: r.artl@iaea.org
Batandjieva, B.	Department of Nuclear Safety and Security, International Atomic Energy Agency, Wagramer Strasse 5, P.O. Box 100, A-1400 Vienna, AUSTRIA Fax: +43126007 E-mail: b.batandjieva@iaea.org
Bichler-Bell, N.	Department of Management, International Atomic Energy Agency, Wagramer Strasse 5, P.O. Box 100, A-1400 Vienna, AUSTRIA Fax: +43126007 E-mail: n.bichler-bell@iaea.org
Biggs, I.D.	Office of the Director General, International Atomic Energy Agency, Wagramer Strasse 5, P.O. Box 100, A-1400 Vienna, AUSTRIA Fax: +43126007 E-mail: i.d.biggs@iaea.org
Boussaha, A.	Department of Technical Co-operation, International Atomic Energy Agency, Wagramer Strasse 5, P.O. Box 100, A-1400 Vienna, AUSTRIA Fax: +43126007 E-mail: a.boussaha@iaea.org
Brander, S.	Office of Legal Affairs, International Atomic Energy Agency, Wagramer Strasse 5, P.O. Box 100, A-1400 Vienna, AUSTRIA Fax: +43126007 E-mail: s.brander@iaea.org

Brockman, K.
Department of Nuclear Safety and Security,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: k.brockman@iaea.org

Burns, K.
Department of Nuclear Sciences and Applications,
International Atomic Energy Agency,
A-2444 Seibersdorf,
AUSTRIA
Fax: +43126007
E-mail: k.i.burns@iaea.org

Cameron, R.
Department of Nuclear Safety and Security,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: r.cameron@iaea.org

Cardoso, A.J.
Department of Technical Co-operation,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: a.j.cardoso@iaea.org

Cetto, A.M.
Department of Technical Co-operation,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: a.cetto@iaea.org

Chaudhri, S.
Department of Technical Co-operation,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: s.chaudhri@iaea.org

Crick, M.
Department of Nuclear Safety and Security,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: m.crick@iaea.org

Cserveny, V.
Office of External Relations and Policy Co-ordination,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: v.cserveny@iaea.org

de Klerk, P.
Office of External Relations and Policy Co-ordination,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: p.deklerk@iaea.org

Dey, S.
Department of Technical Co-operation,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: s.dey@iaea.org

Dodd, B.
Department of Nuclear Safety and Security,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: b.dodd@iaea.org

Dolan, T.
Department of Nuclear Safety and Security,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: t.dolan@iaea.org

Efremenkov, V.
Department of Nuclear Energy,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: v.efremenkov@iaea.org

ElBaradei, M.
Director General,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: ElBaradei@iaea.org

Ferruz-Cruz, P.
Department of Technical Co-operation,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: p.ferruz-cruz@iaea.org

Fischer, D.M.
Department of Safeguards,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: d.fischer@iaea.org

Friedrich, V.
Department of Nuclear Safety and Security,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: v.friedrich@iaea.org

Fukuda, K.
Department of Nuclear Energy,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: k.fukuda@iaea.org

Gaggl, K.
Department of Nuclear Sciences and Applications,
International Atomic Energy Agency,
A-2444 Seibersdorf,
AUSTRIA
Fax: +43126007
E-mail: k.gaggl@iaea.org

Glew, M.S.
Department of Nuclear Safety and Security,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: m.glew@iaea.org

González, A.J.
Department of Nuclear Safety and Security,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: a.gonzalez@iaea.org

Guerpinar, A.
Department of Nuclear Safety and Security,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: a.guerpinar@iaea.org

Gwozdecky, M.
Department of Management,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: m.gwozdecky@iaea.org

Hagemann, A.
Department of Nuclear Safety and Security,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: a.hagemann@iaea.org

Hammond, W.
Department of Safeguards,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: w.hammond@iaea.org

Heinonen, O.
Department of Safeguards,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: o.heinonen@iaea.org

Hilliard, J.
Department of Nuclear Safety and Security,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: j.hilliard@iaea.org

Hoskins, R.
Department of Nuclear Safety and Security,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: r.hoskins@iaea.org

Hossain, S.
Department of Nuclear Energy,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: s.hossain@iaea.org

Ikonomou, P. — Department of Safeguards,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: p.ikonomou@iaea.org

Ito, M. — Department of Nuclear Safety and Security,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: m.ito@iaea.org

Kawabata, K. — Department of Nuclear Energy,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: k.kawabata@iaea.org

Khangi, F. — Department of Technical Co-operation,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: f.a.khangi@iaea.org

Kim, B.-K. — Department of Technical Co-operation,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: b-k.kim@iaea.org

Kim, Sok-Chul
Department of Nuclear Safety and Security,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: s.kim@iaea.org

Klose, H.
Department of Nuclear Sciences and Applications,
International Atomic Energy Agency,
A-2444 Seibersdorf,
AUSTRIA
Fax: +43126007
E-mail: h.klose@iaea.org

Knapik, J.F.
Department of Nuclear Safety and Security,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: jerzy.knapik@iaea.org

Kopp, H.
Department of Safeguards,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: h.kopp@iaea.org

Legoux, P.
Department of Nuclear Safety and Security,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: p.legoux@iaea.org

Lodding, J.
Office of External Relations and Policy Co-ordination,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: j.lodding@iaea.org

Lozada, J.A.
Department of Technical Co-operation,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: j.a.lozada@iaea.

Maksoudi, M.
Department of Technical Co-operation,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: m.maksoudi@iaea.org

Massera, G.
Department of Nuclear Safety and Security,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: g.massera@iaea.org

McKenna, T.
Department of Nuclear Safety and Security,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: t.mckenna@iaea.org

Meehan, W.J., Jr.
Department of Nuclear Safety and Security,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: w.meehan@iaea.org

Meghzifene, A.
Department of Nuclear Sciences and Applications,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: a.meghzifene@iaea.org

Metcalf, P.	Department of Nuclear Safety and Security, International Atomic Energy Agency, Wagramer Strasse 5, P.O. Box 100, A-1400 Vienna, AUSTRIA Fax: +43126007 E-mail: p.metcalf@iaea.org
Miklush, D.	Department of Technical Co-operation, International Atomic Energy Agency, Wagramer Strasse 5, P.O. Box 100, A-1400 Vienna, AUSTRIA Fax: +43126007 E-mail: d.miklush@iaea.org
Morel, M.A.	Office of Legal Affairs, International Atomic Energy Agency, Wagramer Strasse 5, P.O. Box 100, A-1400 Vienna, AUSTRIA Fax: +43126007 E-mail: m.a.morel@iaea.org
Mrabit, K.	Department of Nuclear Safety and Security, International Atomic Energy Agency, Wagramer Strasse 5, P.O. Box 100, A-1400 Vienna, AUSTRIA Fax: +43126007 E-mail: k.mrabit@iaea.org
Murakami, K.	Department of Safeguards, International Atomic Energy Agency, Wagramer Strasse 5, P.O. Box 100, A-1400 Vienna, AUSTRIA Fax: +43126007 E-mail: k.murakami@iaea.org
Nawada, H.	Department of Nuclear Energy, International Atomic Energy Agency, Wagramer Strasse 5, P.O. Box 100, A-1400 Vienna, AUSTRIA Fax: +43126007 E-mail: h.nawada@iaea.org

Nilsson, A.	Department of Nuclear Safety and Security, International Atomic Energy Agency, Wagramer Strasse 5, P.O. Box 100, A-1400 Vienna, AUSTRIA Fax: +43126007 E-mail: a.nilsson@iaea.org
Nogueira, C.	Department of Nuclear Safety and Security, International Atomic Energy Agency, Wagramer Strasse 5, P.O. Box 100, A-1400 Vienna, AUSTRIA Fax: +43126007 E-mail: c.nogueira@iaea.org
Olsen, R.	Department of Safeguards, International Atomic Energy Agency, Wagramer Strasse 5, P.O. Box 100, A-1400 Vienna, AUSTRIA Fax: +43126007 E-mail: r.olsen@iaea.org
Piderit, G.	Department of Technical Co-operation, International Atomic Energy Agency, Wagramer Strasse 5, P.O. Box 100, A-1400 Vienna, AUSTRIA Fax: +43126007 E-mail: g.piderit@iaea.org
Pope, R.	Department of Nuclear Safety and Security, International Atomic Energy Agency, Wagramer Strasse 5, P.O. Box 100, A-1400 Vienna, AUSTRIA Fax: +43126007 E-mail: r.pope@iaea.org
Rauf, T.	Office of External Relations and Policy Co-ordination, International Atomic Energy Agency, Wagramer Strasse 5, P.O. Box 100, A-1400 Vienna, AUSTRIA Fax: +43126007 E-mail: t.rauf@iaea.org

Rautenbach, J.
Office of Legal Affairs,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: j.rautenbach@iaea.org

Razley, M.N.
Department of Technical Co-operation,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: m.n.razley@iaea.org

Reber, E.
Department of Nuclear Safety and Security,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: e.reber@iaea.org

Riihonen, M.
Department of Nuclear Safety and Security,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: m.riihonen@iaea.org

Roberts, A.
Department of Nuclear Safety and Security,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: a.roberts@iaea.org

Rowat, J.
Department of Nuclear Safety and Security,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: j.rowat@iaea.org

Sabol, J.
Department of Technical Co-operation,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: j.sabol@iaea.org

Samiei, M.
Department of Technical Co-operation,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: m.samiei@iaea.org

Schneider, K.
Department of Nuclear Energy,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: k.scheider@iaea.org

Shea, T.
Department of Safeguards,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: t.shea@iaea.org

Shoaib, K.
Department of Management,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: k.shoaib@iaea.org

Skornik, K.
Department of Technical Co-operation,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: k.skornik@iaea.org

Sohrabi, M. | Department of Technical Co-operation,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: m.sohrabi@iaea.org

Sokolov, F. | Department of Nuclear Energy,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: k.sokolov@iaea.org

Soo Hoo, M.S. | Department of Nuclear Safety and Security,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: m.soohoo@iaea.org

Taniguchi, T. | Department of Nuclear Safety and Security,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: t.taniguchi@iaea.org

Tonhauser, W. | Office of Legal Affairs,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: w.tonhauser@iaea.org

Waller, D.B. | Department of Management,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: d.waller@iaea.org

Weiss, B. Department of Nuclear Safety and Security,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: b.weiss@iaea.org

Wheatley, J. Department of Nuclear Safety and Security,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: j.wheatley@iaea.org

Wrixon, A.D. Department of Nuclear Safety and Security,
International Atomic Energy Agency,
Wagramer Strasse 5, P.O. Box 100,
A-1400 Vienna,
AUSTRIA
Fax: +43126007
E-mail: a.wrixon@iaea.org

INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION (ICRP)

Clarke, R.H. International Commission on Radiological Protection,
c/o National Radiological Protection Board,
Chilton, Didcot,
Oxfordshire, OX11 0RQ,
UNITED KINGDOM
Fax: +441235822619
E-mail: roger.clarke@nrpb.org.uk

INTERNATIONAL CRIMINAL POLICE ORGANIZATION (ICPO-INTERPOL)

Powers, D. Public Safety and Terrorism Sub-Directorate,
International Criminal Police Organization
(ICPO-Interpol),
200 Quai Charles de Gaulle,
F-69006 Lyon,
FRANCE
E-mail: d.powers@interpol.int

INTERNATIONAL SOCIETY OF RADIOLOGY (ISR)

Klempfner, G.
International Society of Radiology,
7910 Woodmont Avenue, Suite 400,
Bethesda, MD 20814,
UNITED STATES OF AMERICA
Fax: +3019078768
E-mail: isr@isradiology.org

Linton, O.W.
International Society of Radiology,
7910 Woodmont Avenue, Suite 400,
Bethesda, MD 20814,
UNITED STATES OF AMERICA
Fax: +3019078768
E-mail: isr@isradiology.org

Ringertz, H.G.
Department of Radiology,
Karolinska Hospital,
SE-17176 Stockholm,
SWEDEN
Fax: +46851776000
E-mail: hans.Ringertz@ks.se

OECD NUCLEAR ENERGY AGENCY

Kessler, C.
OECD Nuclear Energy Agency,
12, Boulevard des Îles,
F-92130 Issy-les-Moulineaux,
FRANCE
Fax: +33145241011
E-mail: carol.kessler@oecd.org

Wagstaff, F.
OECD Nuclear Energy Agency,
12, Boulevard des Îles,
F-92130 Issy-les-Moulineaux,
FRANCE
Fax: +33145241106
E-mail: fiona.wagstaff@oecd.org

ORGANIZATION FOR SECURITY AND CO-OPERATION IN EUROPE (OSCE)

Machl, S.
OSCE Secretariat,
CPC,
Kärntnerring 5–7,
A-1010 Vienna,
AUSTRIA
Fax: +4315143696
E-mail: sabine.machl@osce.org

Zannier, L.
OSCE Secretariat,
CPC,
Kärntnerring 5–7,
A-1010 Vienna,
AUSTRIA
Fax: +4315143696
E-mail: lamberto.zannie@osce.org

PAN AMERICAN HEALTH ORGANIZATION (PAHO)

Arias, C.F.
Department of Physics,
Faculty of Engineering,
University of Buenos Aires,
Paseo Colón 850,
Buenos Aires,
ARGENTINA
E-mail: carias@fi.uba.ar

WORLD CUSTOMS ORGANIZATION (WCO)

Mellwig, R.
World Customs Organization (WCO),
30 Rue du Marché,
B-1210 Brussels,
BELGIUM
Fax: +3222099493
E-mail: Rainer.Mellwig@wcoomd.org

WORLD NUCLEAR ASSOCIATION

Perera, J.M.
World Nuclear Association,
Bowater House,
114 Knightsbridge,
London SW1X 7LJ,
UNITED KINGDOM
Fax: +441442863462
E-mail: judithperera@aol.com

WORLD NUCLEAR TRANSPORT INSTITUTE (WNTI)

Dixon, T.I.	World Nuclear Transport Institute, 7 Old Park Lane, 6th Floor, London WIK 1QR, UNITED KINGDOM Fax: +4402074951964 E-mail: wnti@wnti.co.uk

OBSERVERS

Al-Kubaisi, S.A.	Qatar Petroleum, P.O. Box 47, Doha, QATAR Fax: +9744402806 E-mail: s_alkubasi@qp.comqa
Al-Wahaibi, S.S.A.	Ministry of Health, P.O. Box 393, PC 113, Mina Al-Fahk, Muscat, OMAN Fax: +968863121 E-mail: enmal898@omantel.net.em
Dietrich, M.	Permanent Mission of the United States of America to the International Atomic Energy Agency, Wagramer Strasse 17–19, A-1220 Vienna, AUSTRIA
Hurt, G.	Permanent Mission of the United States of America to the International Atomic Energy Agency, Wagramer Strasse 17–19, A-1220 Vienna, AUSTRIA
Ogungbemile, O.O.	Nigeria Customs Service Headquarters, Abidjan Street, Wuse Zone 3, Abuja, NIGERIA

Ring, J.P.

Harvard University,
1230 Soldiers Field Road,
Cambridge, MA 02138,
UNITED STATES OF AMERICA
Fax: +16174965509
E-mail: joseph_ring@harvard.edu

Walsh, J.

Managing the Atom Project,
Harvard University,
79 John F. Kennedy Street,
Cambridge, MA 02138,
UNITED STATES OF AMERICA
Fax: +16174960606
E-mail: James_Walsh@harvard.edu

AUTHOR INDEX